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TECHNICAL MEMORANDUM

To: Brett Musick, PE
Senior Engineer
City of Newberg

From: Jake Johnston, PE
Civil Engineer
3J Consulting, Inc.

Date: December 18, 2019

Project Name: **East Crestview Drive Improvement Project**
Project No: **19525**
Subject: **Westlake Loop Mini-Roundabout**

This memorandum will discuss mini-roundabout options for the intersection of East Crestview Drive and Westlake Loop.

Preliminary designs were prepared for two mini-roundabouts of different inscribed circle diameters and analyzed for geometric design including vehicle turning movements, intersection sight distance, right-of-way needs, and subsequent safety (based on NCHRP Report 672).

MINI-ROUNDABOUTS

NCHRP 672 distinguishes mini-roundabouts from traditional roundabouts by their smaller size and more compact geometry. They are most commonly used in low-speed urban environments with right-of-way constraints and typically designed for negotiating speeds of 15 mph, which makes them suitable for the intersection of East Crestview Drive and Westlake Loop. Figure 1 shows the features of a typical mini-roundabout and Table 1 summarizes and compares some fundamental design and operational elements for each of the three roundabout categories.

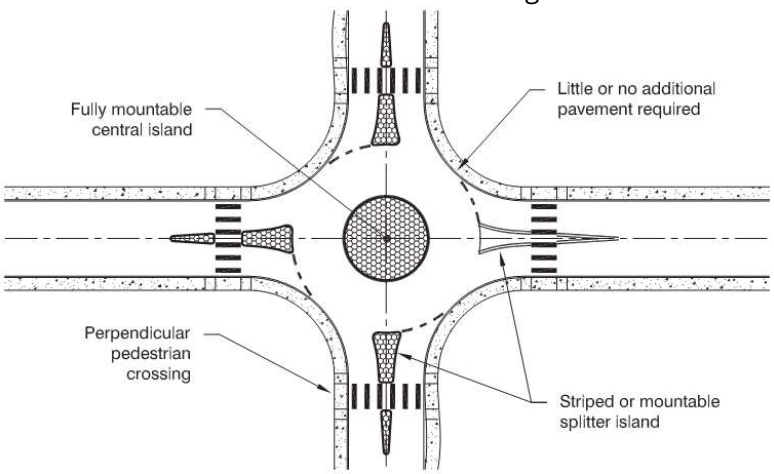


Figure 1 – Features of a Typical Mini-Roundabout

Design Element	Mini-Roundabout	Single-Lane Roundabout	Multilane Roundabout
Desirable maximum entry design speed	15 to 20 mph (25 to 30 km/h)	20 to 25 mph (30 to 40 km/h)	25 to 30 mph (40 to 50 km/h)
Maximum number of entering lanes per approach	1	1	2+
Typical inscribed circle diameter	45 to 90 ft (13 to 27 m)	90 to 180 ft (27 to 55 m)	150 to 300 ft (46 to 91 m)
Central island treatment	Fully traversable	Raised (may have traversable apron)	Raised (may have traversable apron)
Typical daily service volumes on 4-leg roundabout below which may be expected to operate without requiring a detailed capacity analysis (veh/day)*	Up to approximately 15,000	Up to approximately 25,000	Up to approximately 45,000 for two-lane roundabout

*Operational analysis needed to verify upper limit for specific applications or for roundabouts with more than two lanes or four legs.

Table 1 – Roundabout Category Comparison

Because of their mountable nature, mini-roundabouts do not provide the same degree of visibility and channelization provided by larger roundabouts with raised islands. As a result, mini-roundabouts have some notable limitations in application as found in the alternatives that will be discussed later in this memo:

- Mini-roundabouts are not recommended in locations in which high U-turn traffic is expected. Due to the radius restrictions of the small inscribed circle diameter, larger vehicles may not be capable of making a U-turn.
- Mini-roundabouts are not well suited for high volumes of trucks, as trucks will occupy most of the intersection when turning, significantly reducing the capacity of the mini-roundabout. Additionally, high volumes of trucks overrunning the central island may lead to rapid wear of the roadway markings.

PERFORMANCE CHECKS

Fastest Path

The fastest path allowed by the geometry determines the negotiation speed for that particular movement into, through, and exiting the roundabout. It is the smoothest, flattest path possible for a single vehicle, in the absence of other traffic and ignoring all lane markings. It represents the theoretical attainable entry speeds, not expected vehicle speeds, for design purposes. Actual speeds will vary. NCHRP 672 recommends a maximum theoretical entry design speed of 20 mph for mini-roundabouts. Through movements are usually the fastest path, though right-turn movements could be faster at some roundabouts. Figure 2 illustrates the five critical path radii that have been checked for each approach. R1 is the *entry path radius*, R2 is the *circulating path radius*, R2 is the *exit path radius*, R4 is the *left-turn path radius*, and R5 is the *right-turn path radius*.

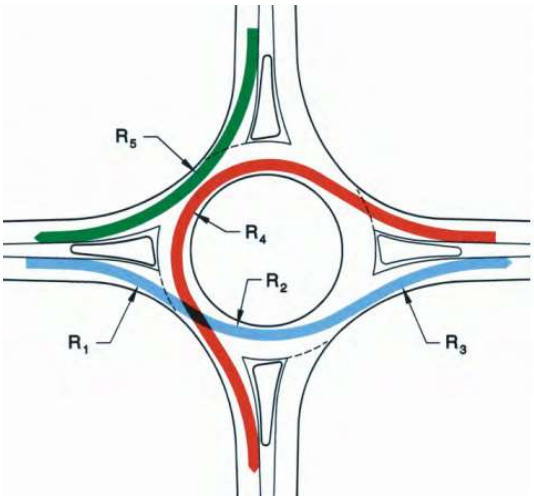


Figure 2 - Vehicle Path Radii

The relationship between travel speed and horizontal curvature as documented in the AASHTO "Greenbook" was used to estimate the maximum theoretical entry design speed for each alternative.

Stopping Sight Distance

Three critical types of locations were checked for stopping sight distance:

1. Approach sight distance (Figure 3),
2. Sight distance on circulatory roadway (Figure 4), and
3. Sight distance to crosswalk on exit (Figure 5).

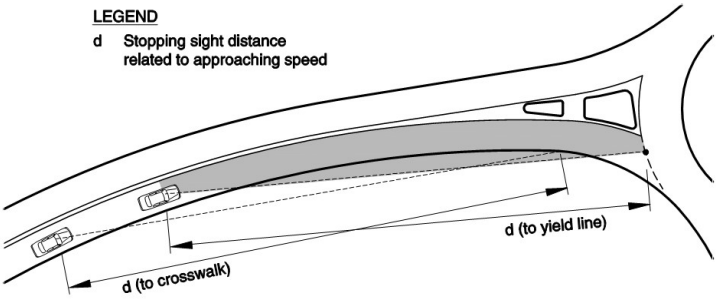


Figure 3 – Stopping Sight Distance on the Approach

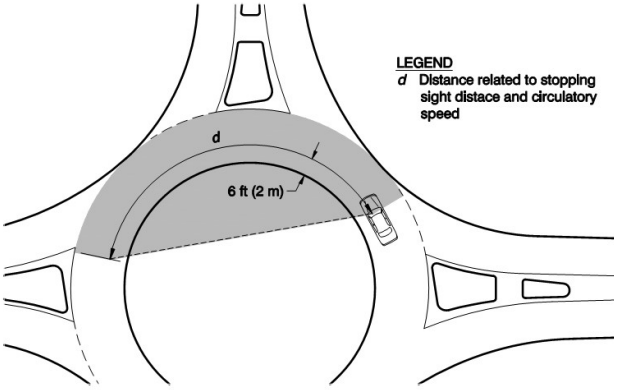


Figure 4 – Stopping Sight Distance on Circulatory Roadway

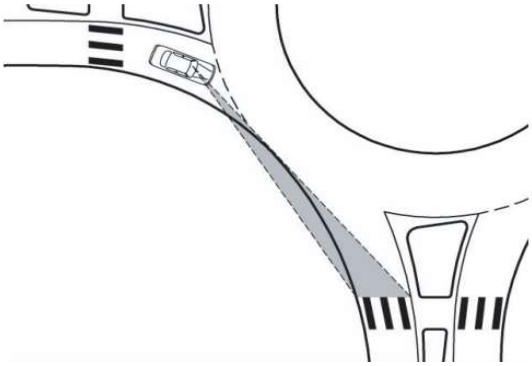


Figure 5 – Stopping Sight Distance to Crosswalk on Exit

Sight obstructions based on eye and object heights were not investigated as part of this analysis. No visible horizontal obstructions were identified for either alternative.

Intersection Sight Distance

International evidence suggests that it is advantageous to provide no more than the minimum required intersection sight distance on each approach. Excessive sight distance can lead to higher vehicle speeds that reduce the safety of the intersection for all road users (motorists, bicyclists, pedestrians). Sight obstructions based on eye and object heights were not investigated as part of this analysis. However, a wall and fence at the southwest and southeast corners of the intersection were taken into consideration for measuring the available sight distance that exists today (see Exhibits A3 and B3.1 thru B3.3). Figure 6 presents a diagram showing the method for determining intersection sight distance and Table 2 shows the computed distance based on conflicting approach speed.

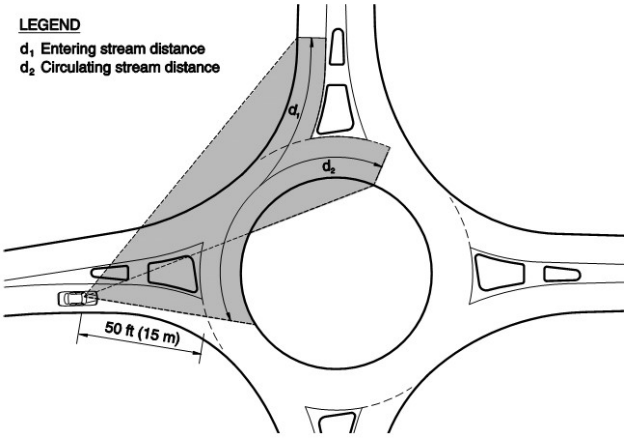


Figure 6 – Intersection Sight Distance

Conflicting Approach Speed (mph)	Computed Distance (ft)
10	73.4
15	110.1
20	146.8
25	183.5
30	220.2

Table 2 – Computed Length of Conflicting Leg of Intersection Sight Triangle

The average of R1 and R2 speeds calculated using the fastest path methodology are used to determine the recommended intersection sight distance. Intersection sight distance values are also based on a NCHRP 672 suggested critical headway for vehicles entering the roundabout of 5 seconds as critical

headway values vary across states from 4.5 to 6.5 seconds. Washington State DOT recommends 4.5 seconds, which applied to this project could reduce the recommended intersection sight distance values by 10%.

Design Vehicle
The intersection design vehicle and the context of the location was taken into consideration for size and selection of the inscribed circle diameters. The typical design vehicle for mini-roundabouts is the SU-30 Single Unit Truck.

The analysis includes vehicle turning movements for a Passenger Car (P), Single Unit Truck (SU-30), 30-ft Motor Home (MH), 30-ft Motor Home and Boat Trailer (MH/B) and modified 40-ft Motor Home and Boat Trailer (see list of exhibits at end of memo for vehicle turning movements). Autodesk's Vehicle Tracking (2020) software was used for analyzing vehicle turning movements at 5 mph.

Preliminary analysis included a modified 40-ft Motor Home and Boat Trailer, originally considered an assumed largest vehicle to be used in this residential area. Turning movements reveal significant conflicts with tracking of curbs, planter areas, and islands. The design team along with City staff discussed the implications of accommodating such a large vehicle. Some of those implications include constructing hardscaping in the planter strip and shifting pedestrian crosswalks further away from the intersection. The project team concluded that the expected impacts, occasional usage, and context of this location did not support the geometric design of accommodating a 40' Motor Home and Boat Trailer to maximum extent. Therefore, the modified 40-ft Motor Home and Boat Trailer is not considered as a design parameter for the geometric design of the mini-roundabout at this time.

ALTERNATIVES

Alternative A – 76-ft Mini-Roundabout

A roundabout concept plan was developed for the City of Newberg in 2007 for the 3-way intersection of Crestview Drive and Westlake Loop. Alternative A has modified this concept to conform with current roundabout design guidance and fit within the footprint of the proposed 4-way intersection at East Crestview Dr and Westlake Loop, resulting in an inscribed circle diameter of 76-ft and central island diameter of 40-ft. See Exhibit A1. This alternative conforms to City road section dimensions providing for normal usage by accommodating the design vehicle (SU-30).

The fastest path was found for the northbound through movements with a max theoretical entry design speed of 31.6 mph, above the target 20 mph. The interim fastest path was found for the westbound through movement for a speed of 25.4 mph, since the north leg of the intersection will not be built with this project. See Exhibit A2. Increasing the central island and inscribed circle is one way to reduce entry speeds, as seen in Alternative B. Additional investigation would be needed to determine the optimum size for lower and safer roundabout entry speeds.

Existing brick walls at the southwest and southeast quadrants obstruct the drivers view and coincidentally limits the available intersection sight distance to 96-ft for both the westbound and northbound approaches. An approach speed of 13 mph was calculated based on the measured

entering stream distance of 96-ft. The recommended intersection sight distance for the northbound and westbound approaches are 151-ft and 159-ft, respectively. See Exhibit A3.

A Single Unit Truck (SU-30) is accommodated by traversing over the central island. Passenger cars are fully accommodated within the circulatory lane (i.e. without traversing the central island). Turning movements for a Motor Home and Boat Trailer require traversable splitter islands as well to be accommodated. NCHRP 672 states that splitter islands can either be raised, traversable or simply striped. However, right-turn movements by the 40-ft Motor Home requires tracking behind the curb return into the planter strip and sidewalk as shown on Exhibit A6. Therefore, a second alternative was developed to avoid tracking of curbs and sidewalk.

Alternative B – 86-ft Mini-Roundabout

An inscribed circle diameter of 86-ft and central island diameter of 50-ft was selected for the second alternative. This alternative requires a larger intersection, including larger curb return radii and additional right-of-way at all four corners, to accommodate larger vehicles such as a 40-ft Motor Home and Boat Trailer without tracking onto the sidewalk. See Exhibit B1. This alternative does not conform to City standard road section widths and is considered a worst-case scenario for accommodating the occasional largest assumed vehicle.

The proposed right-of-way is based on maintaining a minimum of 1-ft behind the back of walk. The proposed sidewalk is located to accommodate tracking of a 40-ft Motor Home and Boat Trailer within the planter area, with suggested hardscaping, without tracking onto the sidewalk. Also, while maintaining a minimum 2-ft planter width per NCHRP 672.

The fastest path was found for the westbound and southbound right-turn movements for a max theoretical entry design speed of 17.9 mph. The interim fastest path was found for the eastbound and northbound right-turn movements for a max theoretical entry design speed of 17.5 mph. See Exhibit B2. Additional investigation would be needed to determine the optimum size for lower and safer roundabout entry speeds, specifically for the northbound through movement.

An existing brick wall at the southwest and southeast quadrants obstruct the drivers view and limits the available intersection sight distance to 99 ft and 95 ft for the northbound and westbound approaches, respectively. The approach speeds were calculated to be 13.5 mph and 13 mph. The recommended intersection sight distance for the northbound and westbound approaches are 140-ft and 155-ft, respectively. See Exhibit B3.

A Single Unit Truck (SU-30) and 30-ft Motor Home (MH) can maneuver through the roundabout without crossing over the central island, splitter islands, or curb returns. For SU-30 and MH turning movements, see Exhibits B4. Turning movements for a Motor Home and Boat Trailer will cross over the central island and still require traversable splitter islands to be accommodated. Right-turn movements by the 40 ft Motor Home require tracking behind the curb return into the planter strip as shown on Exhibits B5 and B6.

Attachments

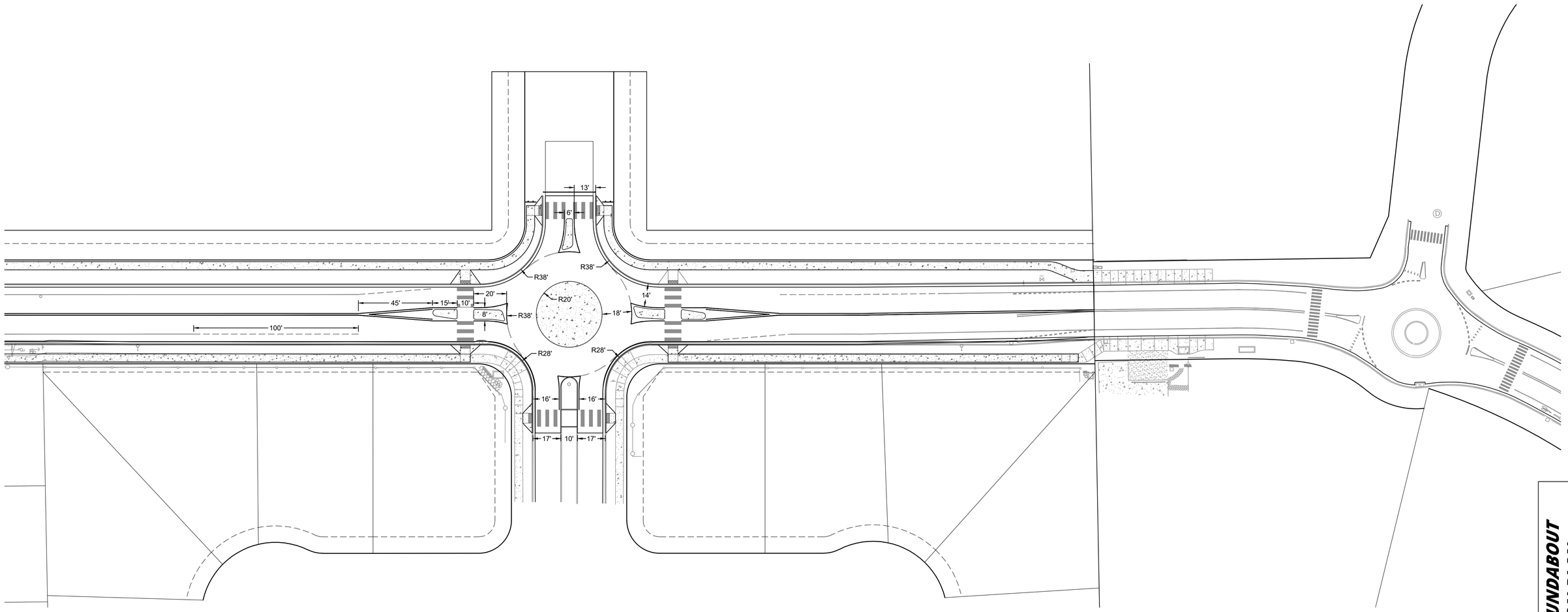
Alternative A

1. Exhibit A1 – Dimension Plan
2. Exhibit A2 – Fastest Path
3. Exhibit A3 – Available Intersection Sight Distance
4. Exhibit A4 – Vehicle Tracking Design Vehicle (SU-30)
5. Exhibit A5 – Vehicle Tracking Assumed Largest Vehicle (40’ MH/B)
6. Exhibit A6 – Vehicle Tracking (P, 30’ MH/B)

Alternative B

7. Exhibit B1 – Dimension Plan
8. Exhibit B2 – Fastest Path
9. Exhibit B3 – Available Intersection Sight Distance
10. Exhibit B4 – Vehicle Tracking Design Vehicles (SU-30 and 30’ MH)
11. Exhibit B5 – Vehicle Tracking Assumed Largest Vehicle (40’ MH/B)
12. Exhibit B6 – Vehicle Tracking & Right-of-Way Impacts (40’ MH/B)
13. Exhibit B7 – Intersection Sight Distance (20 mph approach, 10 mph circulating)
14. Exhibit B8 – Intersection Sight Distance (15 mph approach, 10 mph circulating)
15. Exhibit B9 – Intersection Sight Distance (10 mph approach, 10 mph circulating)

- - - E N D O F D O C U M E N T - - -



76' MINI-ROUNDABOUT DIMENSION PLAN

A1

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WATER RESOURCES
COMMUNITY PLANNING
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DRAWING BY: *JEJ*
PREPARED FOR: *City of Newberg*
PLAN ISSUE DATE: *09/03/2019*
PLAN ISSUE PURPOSE: *Alternative Analysis*

N W E S

SCALE: 1" = 30'
0 30 60 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT

NEWBERG, OREGON

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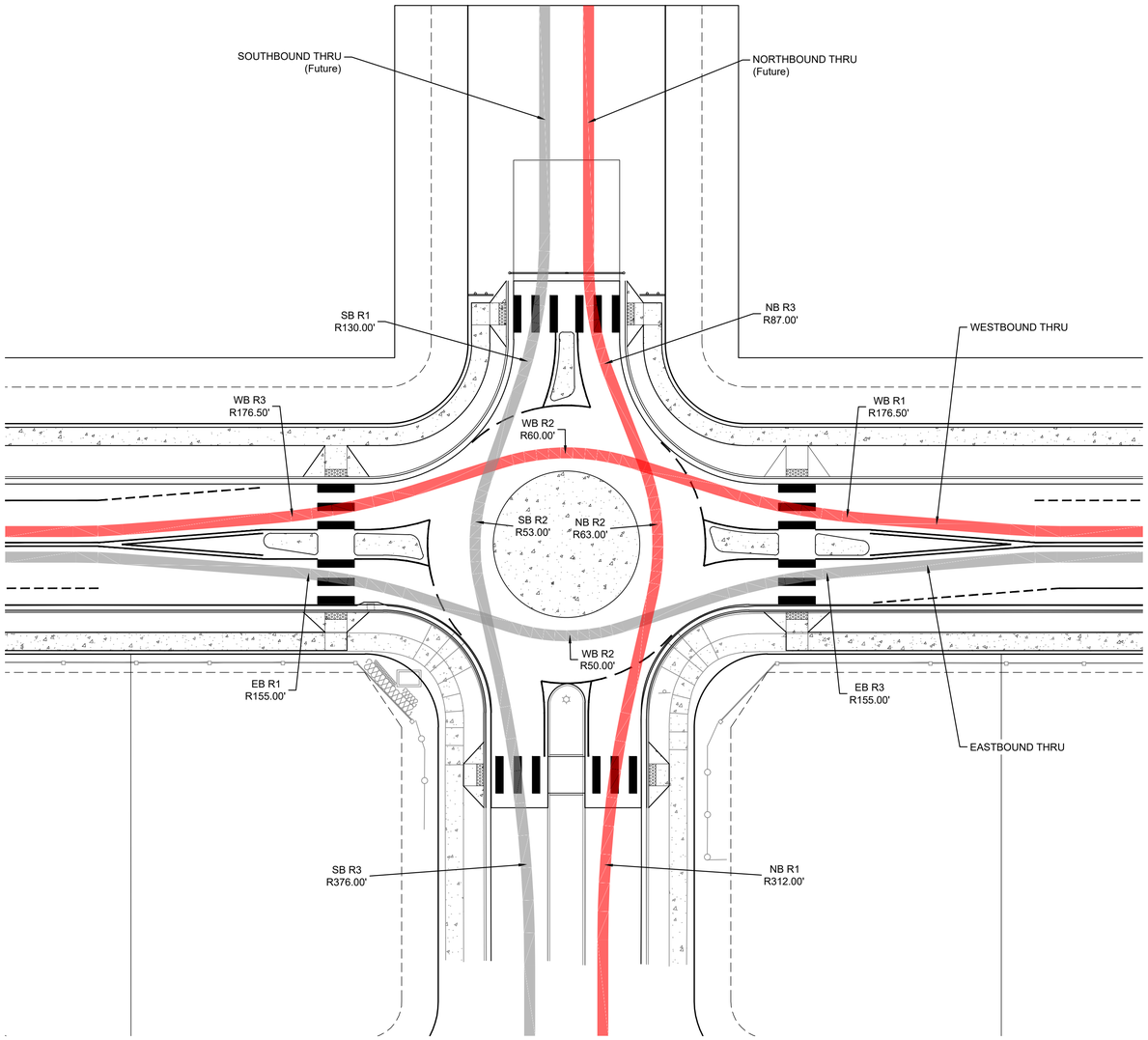
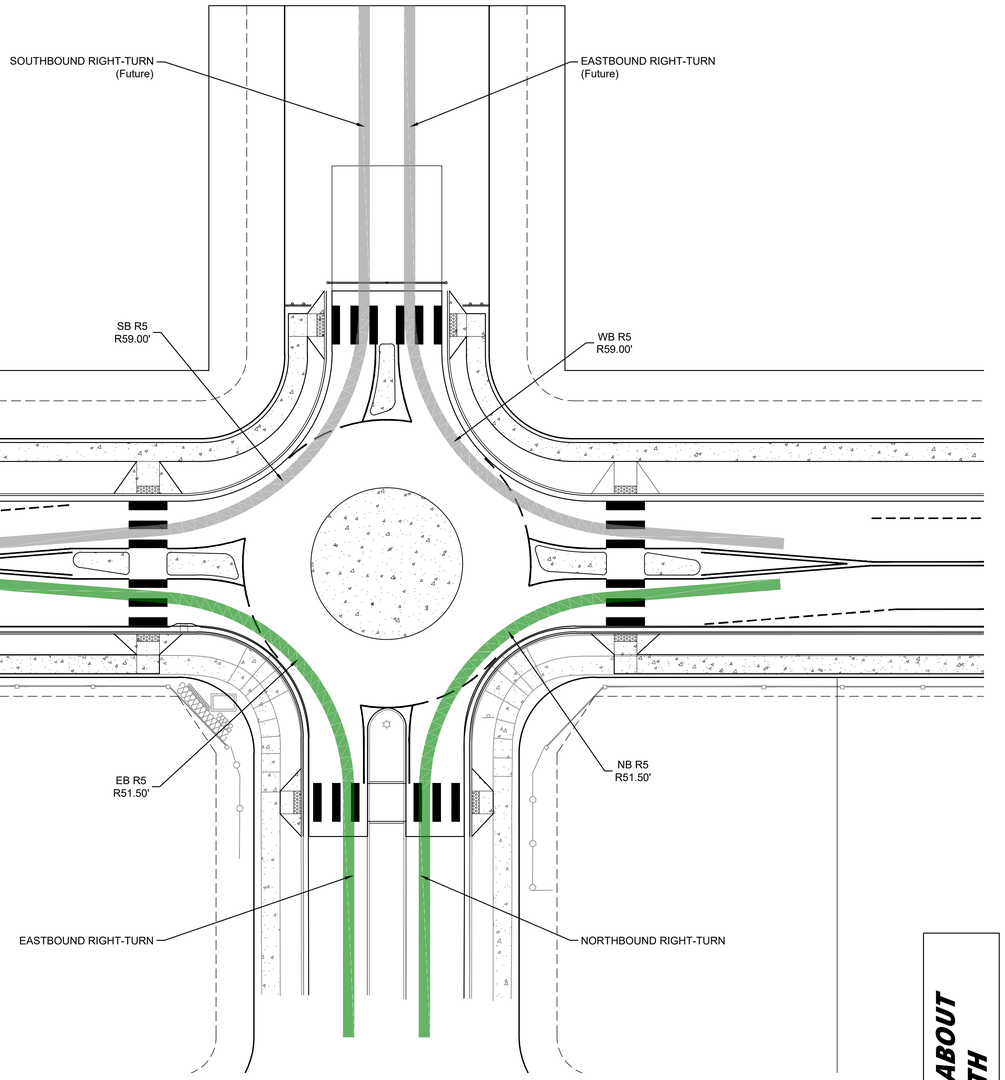


Thru Path Radii
(R1, R2, R3)



Right-Turn Path Radii
(R5)

CALCULATED SPEEDS

DIRECTION	R1 / SPEED	R2 / SPEED	R3 / SPEED	R5
EASTBOUND	155.0' (24.1 mph)	50.0' (15.6 mph)	155.0' (24.1 mph)	51.5' (15.8 mph)
WESTBOUND	176.4' (25.4 mph)	60.0' (16.7 mph)	176.5' (25.4 mph)	59.0' (16.6 mph)
NORTHBOUND	351.0' (31.6 mph)	63.0' (17.0 mph)	87.0' (19.3 mph)	51.5' (15.8 mph)
SOUTHBOUND	130.0' (22.5 mph)	53.0' (15.9 mph)	376.0' (34.0 mph)	59.0' (16.6 mph)

MAXIMUM THEORETICAL ENTRY SPEED *

Interim = Westbound Thru R1 @ 25.4 mph

Future = Northbound Thru R1 @ 31.6 mph

* Recommended max. theoretical entry design speed = 20 mph

76' MINI-ROUNDABOUT
FASTEST PATH

A2

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PLAN ISSUE DATE: ***09/03/2019***
PLAN ISSUE PURPOSE: ***Alternative Analysis***

N W E S

SCALE: 1" = 20'
0 20 40 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT

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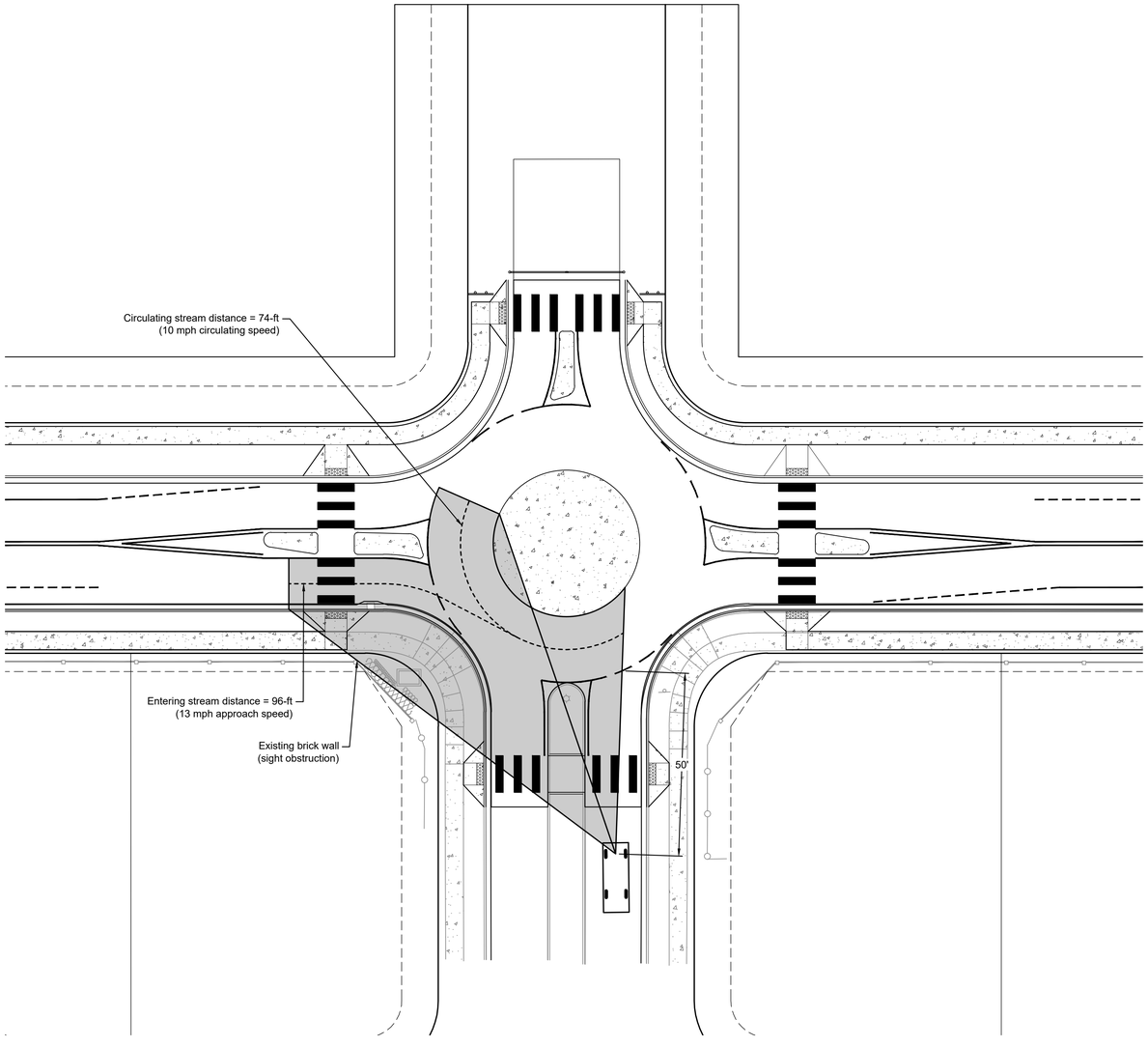
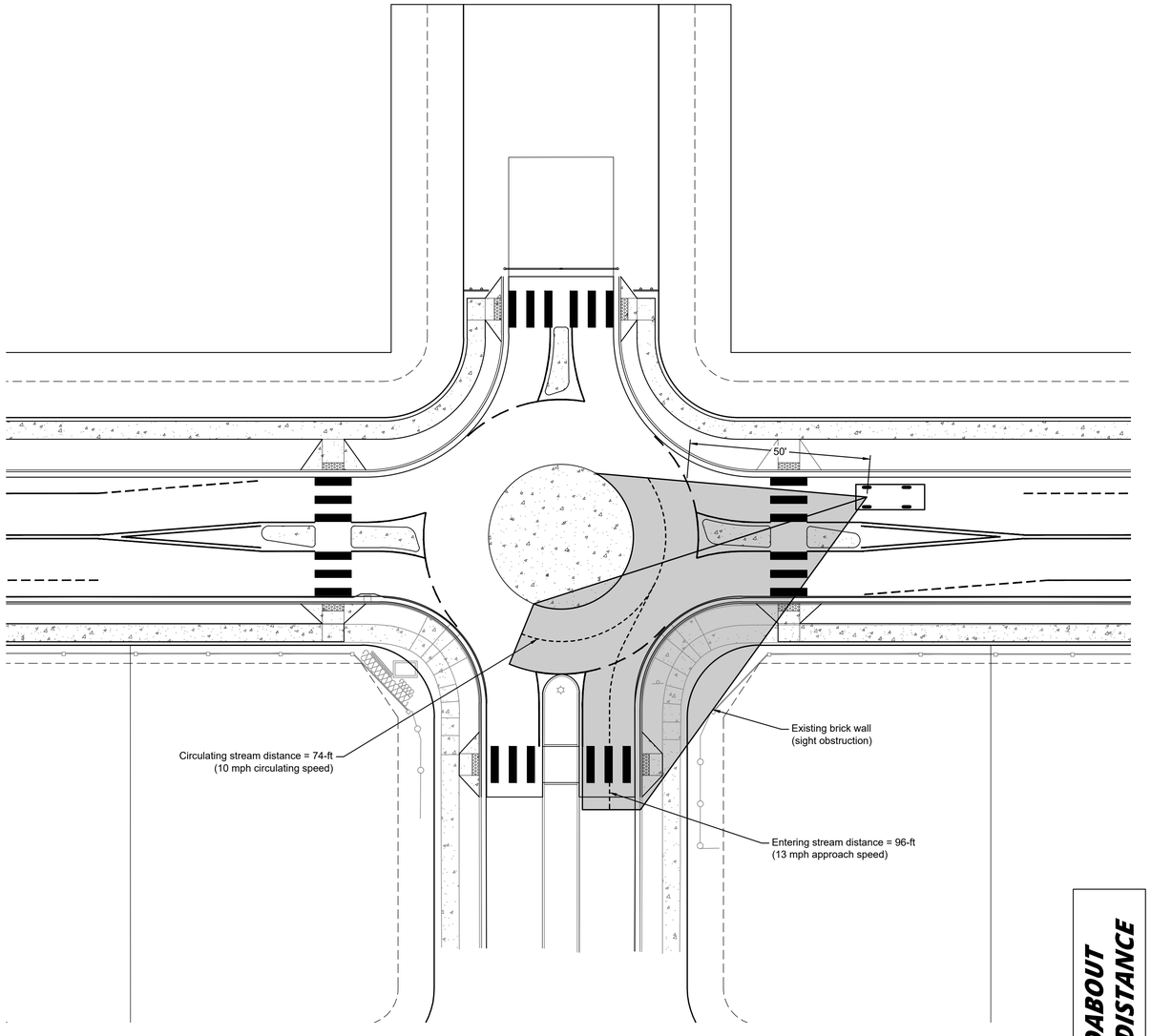


Northbound
Available Intersection Sight Distance = 96-ft
(13 mph conflicting approach speed)

Recommended ISD = 151 ft based on 20.6 mph
conflicting speed (average of R1 and R2)



Westbound
Available Intersection Sight Distance = 96-ft
(13 mph conflicting approach speed)

Recommended ISD = 159 ft based on 118.3 mph
conflicting speed (average of R1 and R2)

76' MINI-ROUNDABOUT
AVAILABLE SIGHT DISTANCE

A3

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N W E S

SCALE: 1" = 20'
0 20 40 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT
NEWBERG, OREGON

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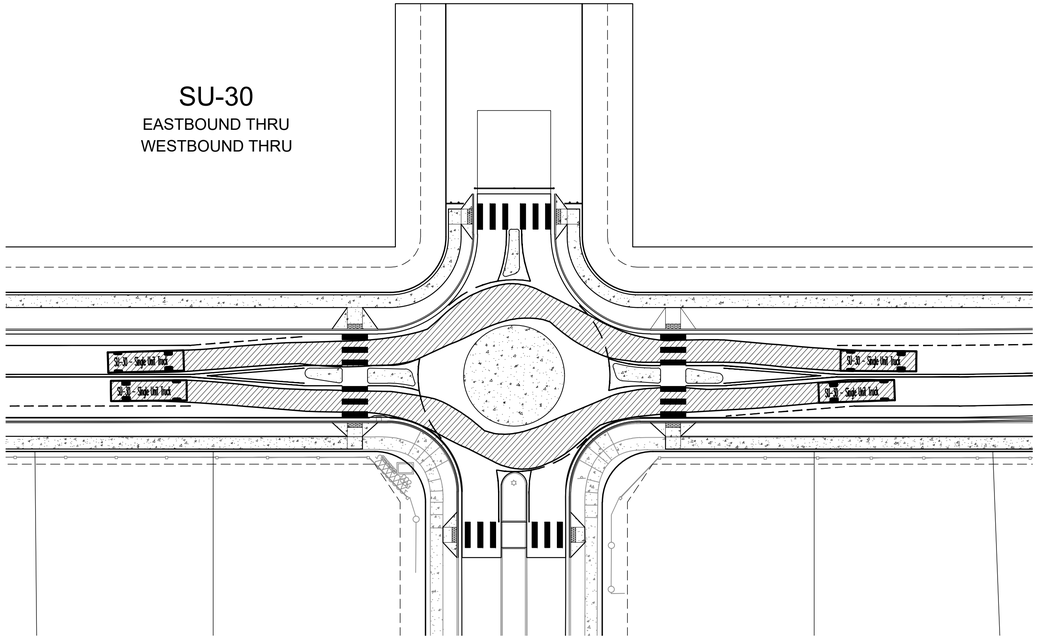
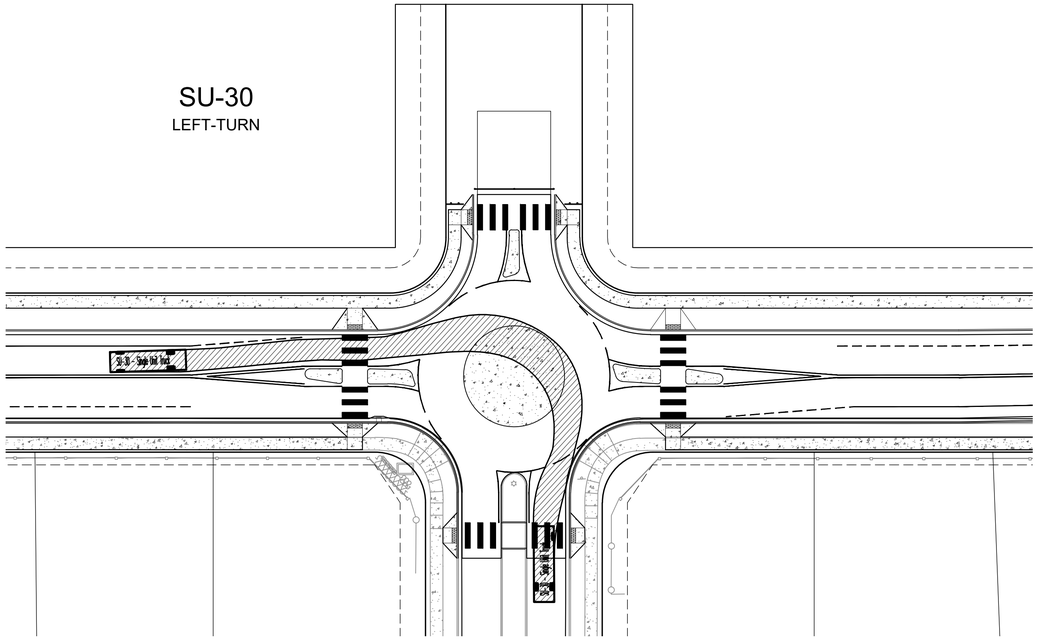
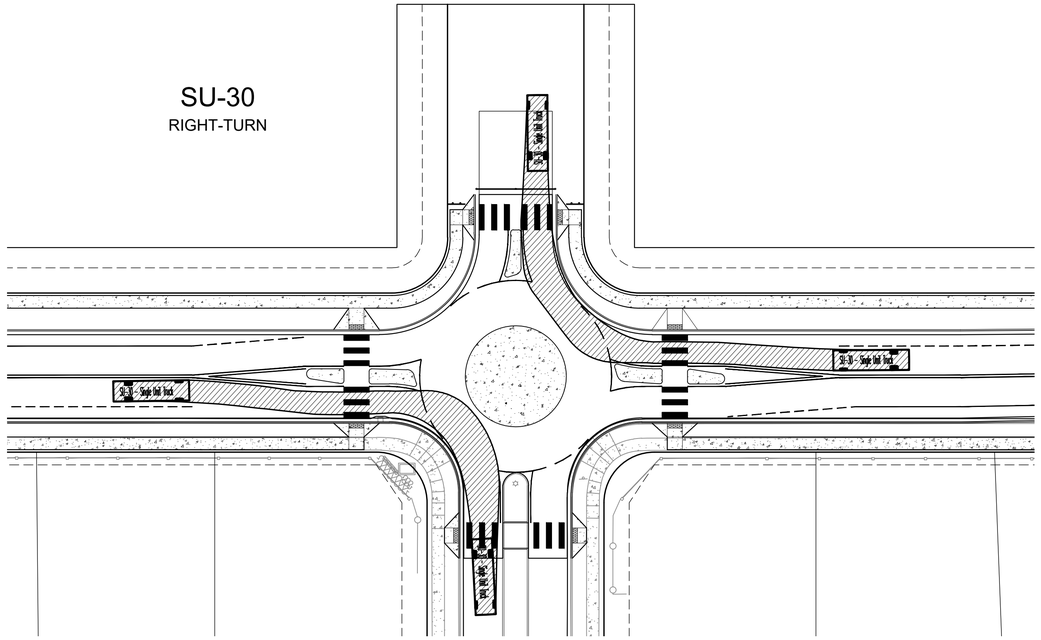


NCHRP Report 672 Recommended Design Vehicle

SU-30 (Single Unit Truck)





76' MINI-ROUNDABOUT VEHICLE TRACKING

Vehicle Tracking 2020
Speed = 5 mph

A4

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PLAN ISSUE DATE: *09/03/2019*
PLAN ISSUE PURPOSE: *Alternative Analysis*

N W E S

SCALE: 1" = 30'
0 30 60 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT

NEWBERG, OREGON

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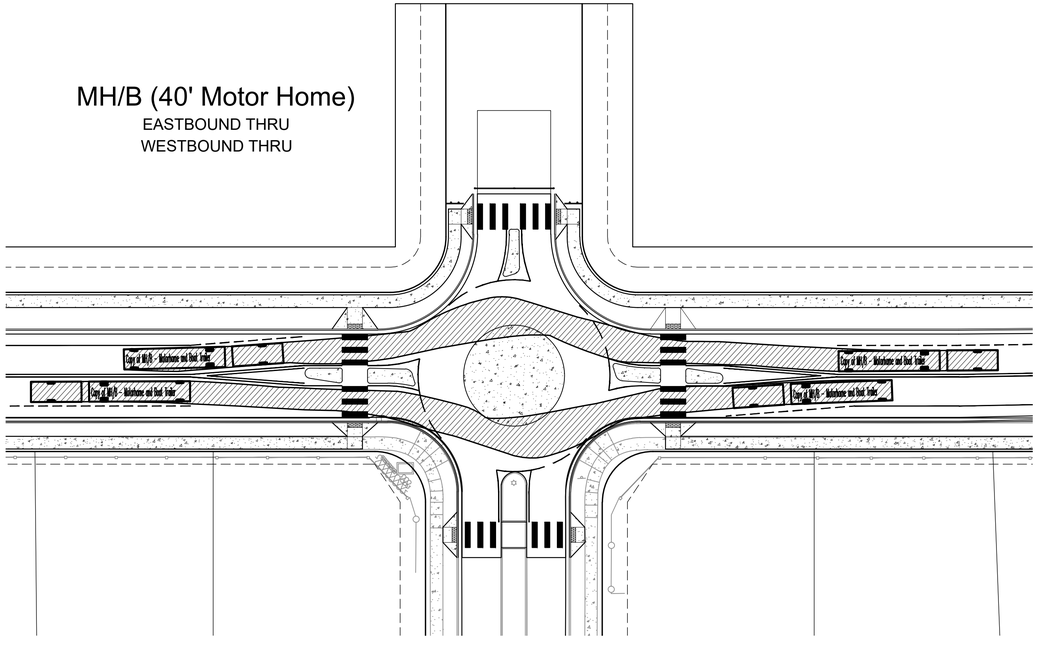
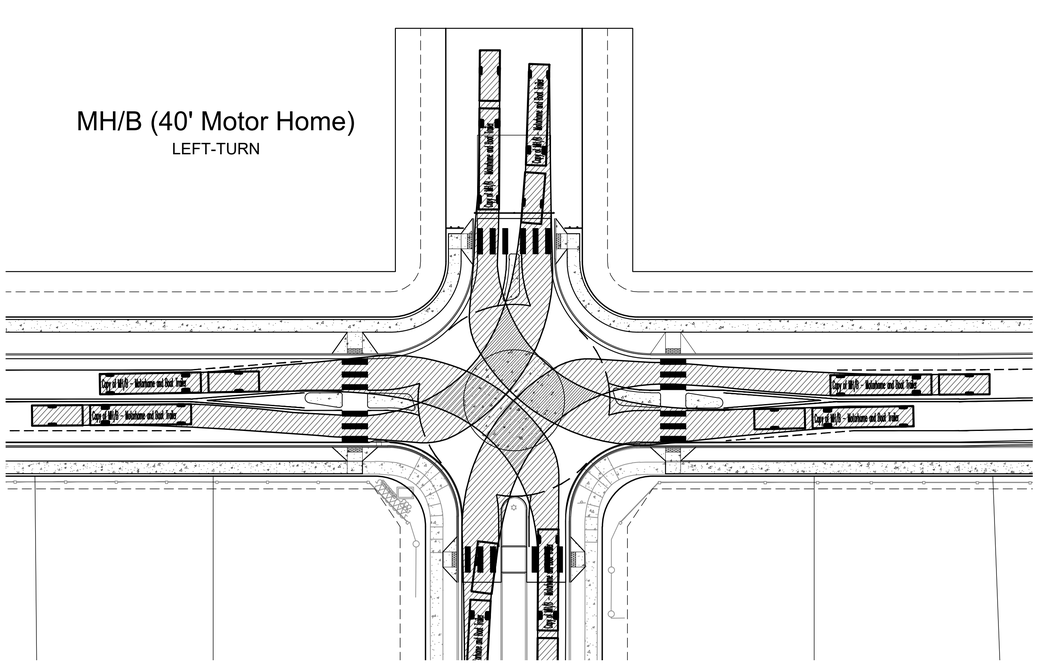
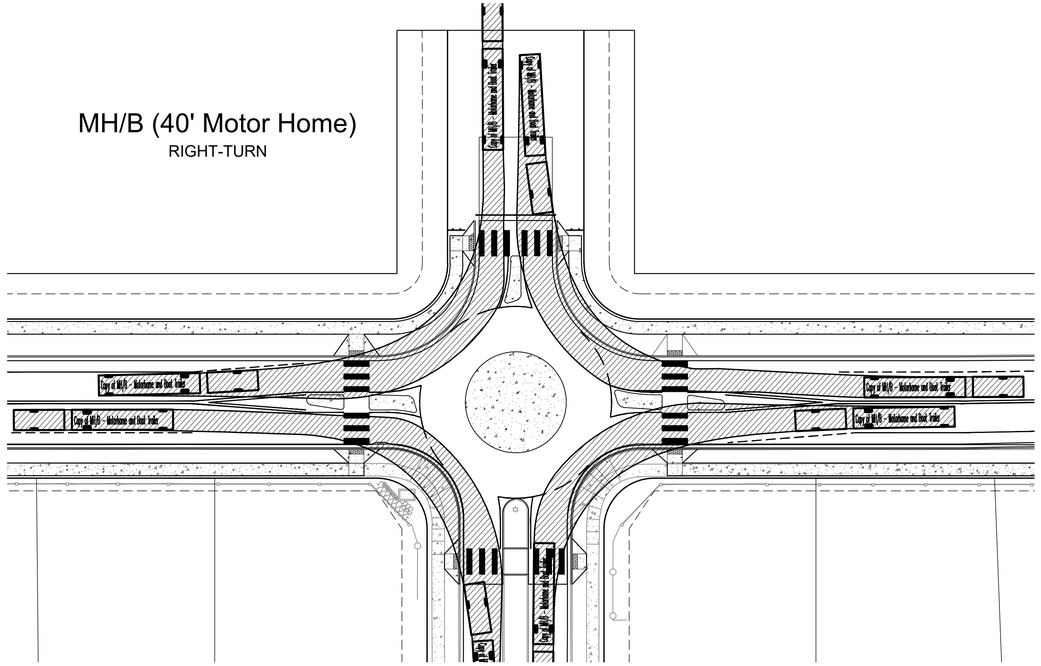


Assumed Largest Vehicle

Modified MH/B (40' Motor Home and Boat Trailer)





76' MINI-ROUNDABOUT VEHICLE TRACKING

Vehicle Tracking 2020
Speed = 5 mph

A5

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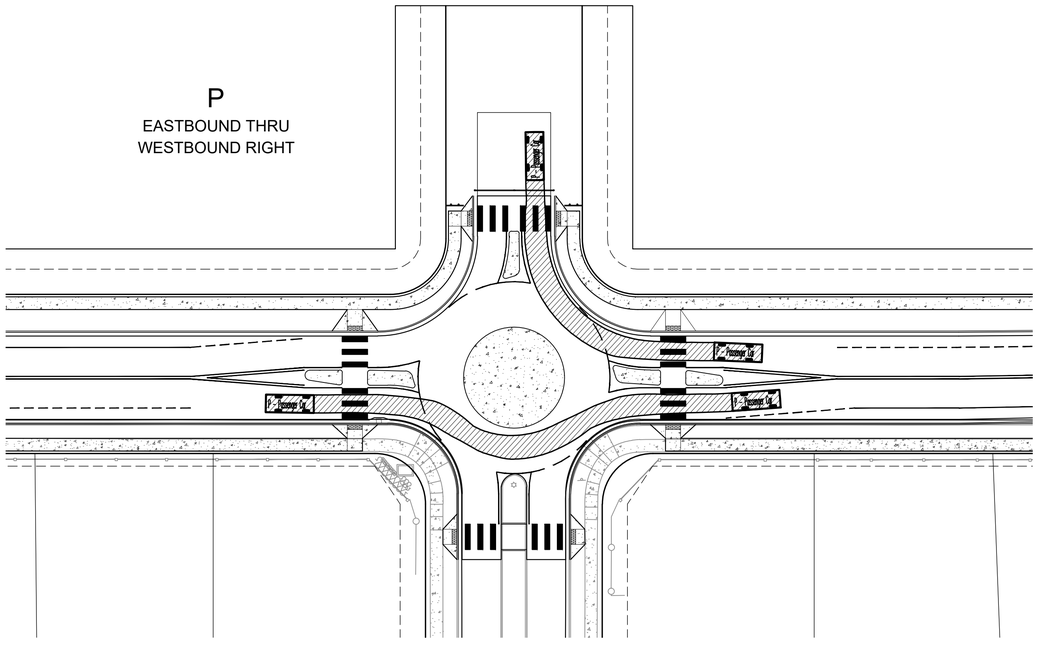
SCALE: 1" = 30'
0 30 60 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT

NEWBERG, OREGON

P
EASTBOUND THRU
WESTBOUND RIGHT



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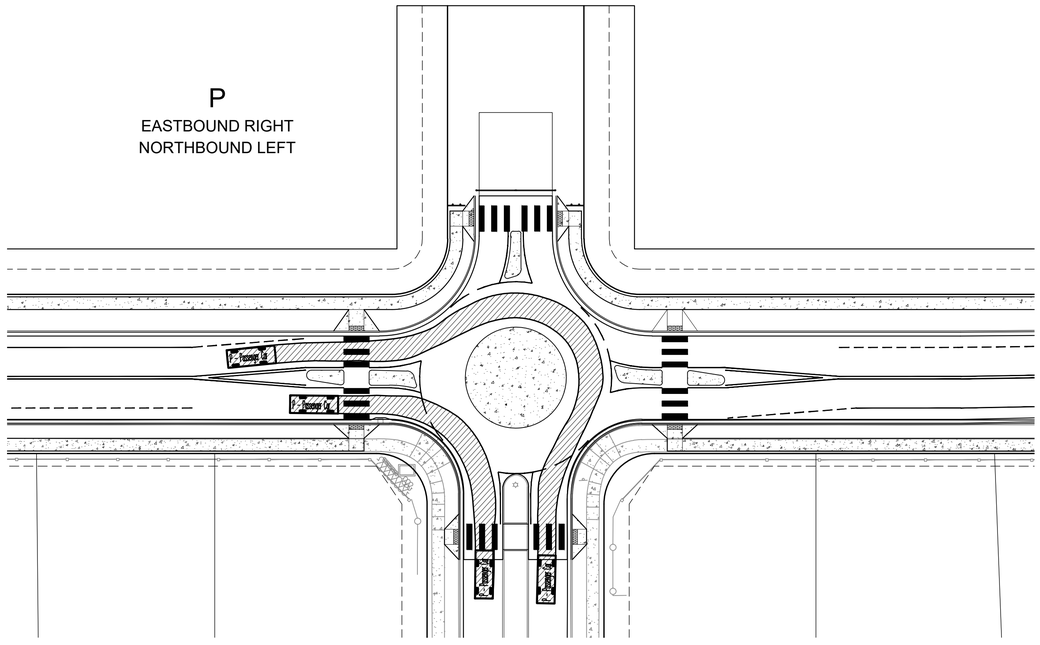
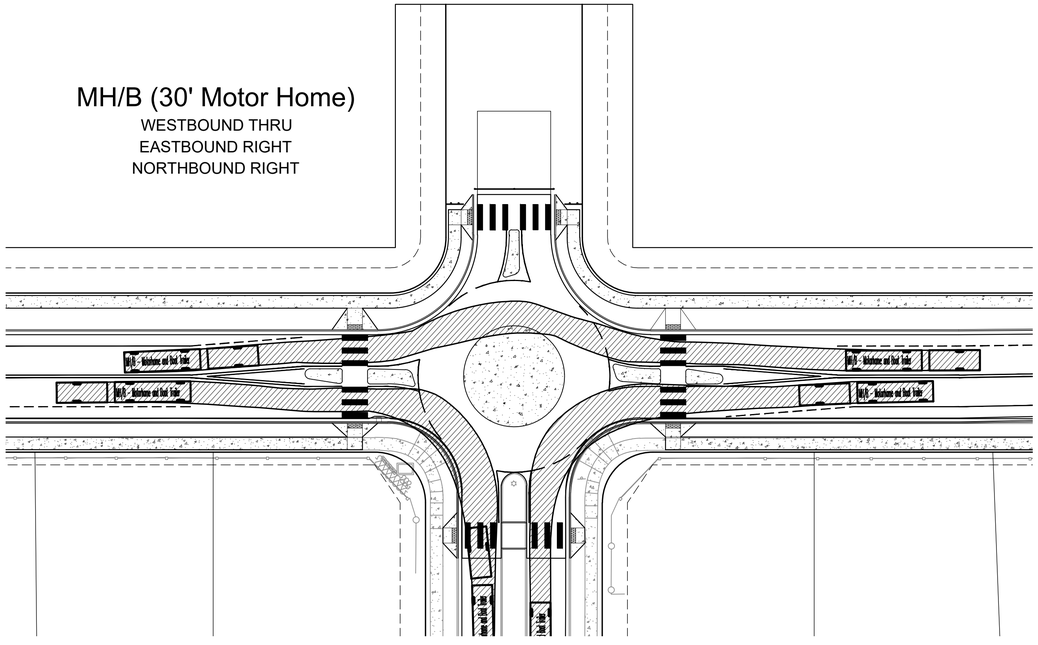
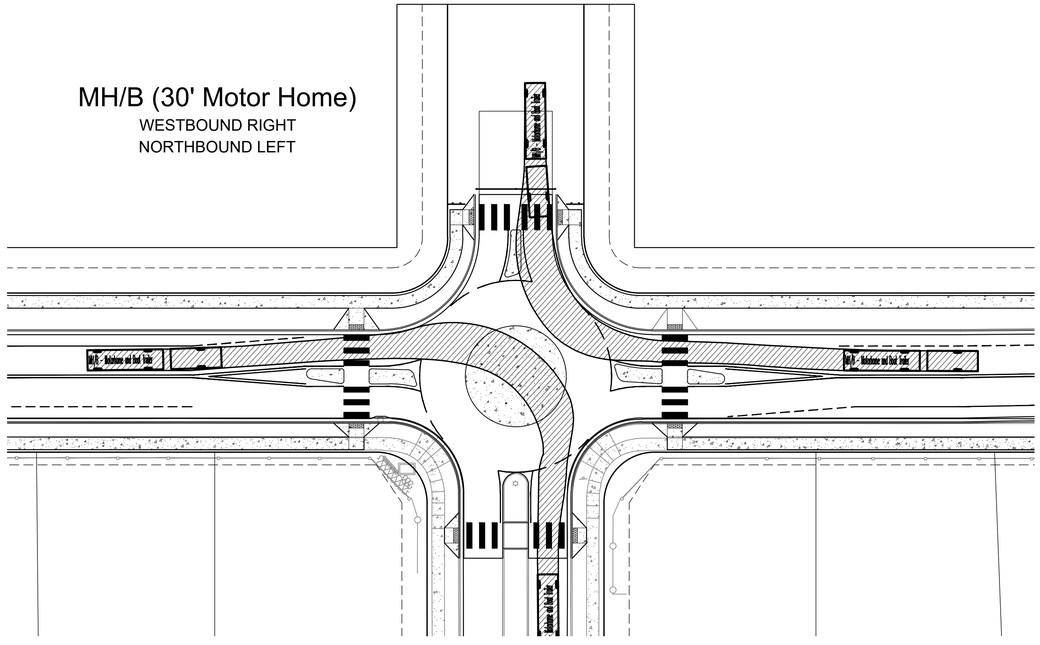
EASTBOUND RIGHT
NORTHBOUND LEFT



MH/B (30' Motor Home)
WESTBOUND THRU
EASTBOUND RIGHT
NORTHBOUND RIGHT



MH/B (30' Motor Home)
WESTBOUND RIGHT
NORTHBOUND LEFT



76' MINI-ROUNDABOUT VEHICLE TRACKING

Vehicle Tracking 2020
Speed = 5 mph

A6

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W E
S

SCALE: 1" = 30'
0 30 60 FT

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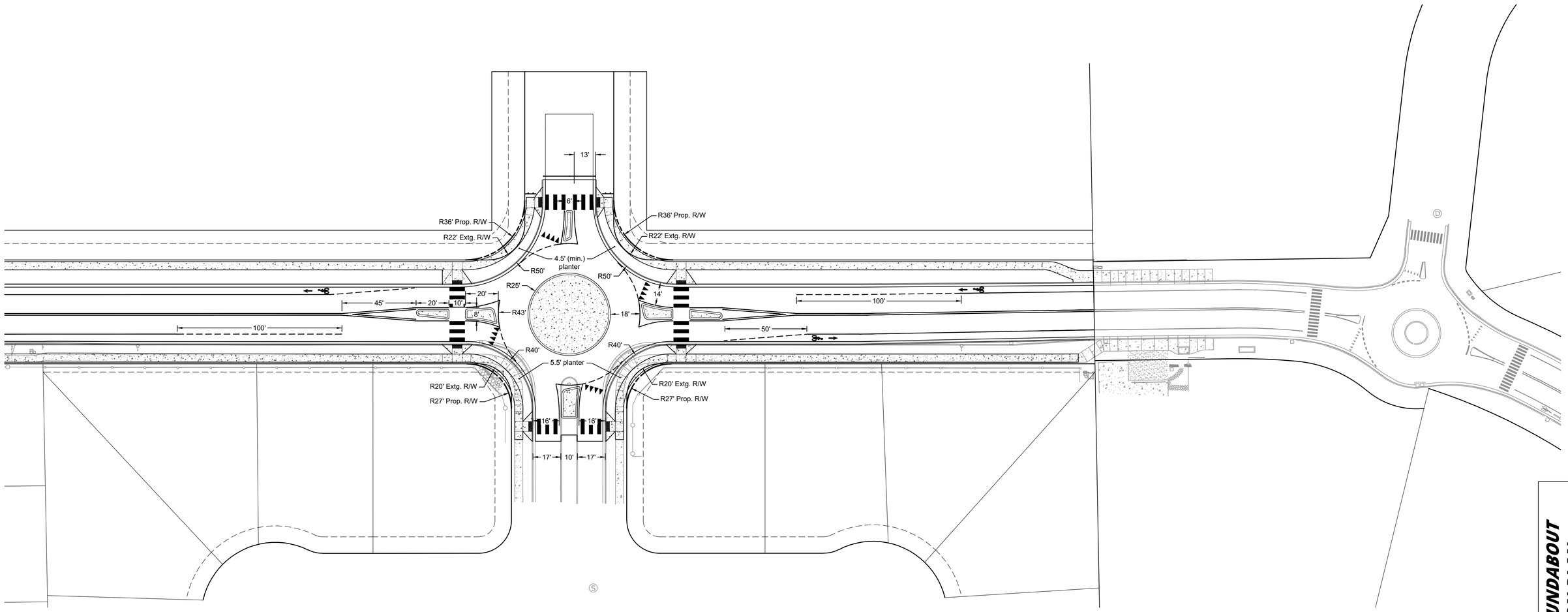

86' MINI-ROUNDABOUT DIMENSION PLAN

B1

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PLAN ISSUE DATE: *12/18/2019*
PLAN ISSUE PURPOSE: *Alternative Analysis*

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SCALE: 1" = 30'
0 30 60 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT

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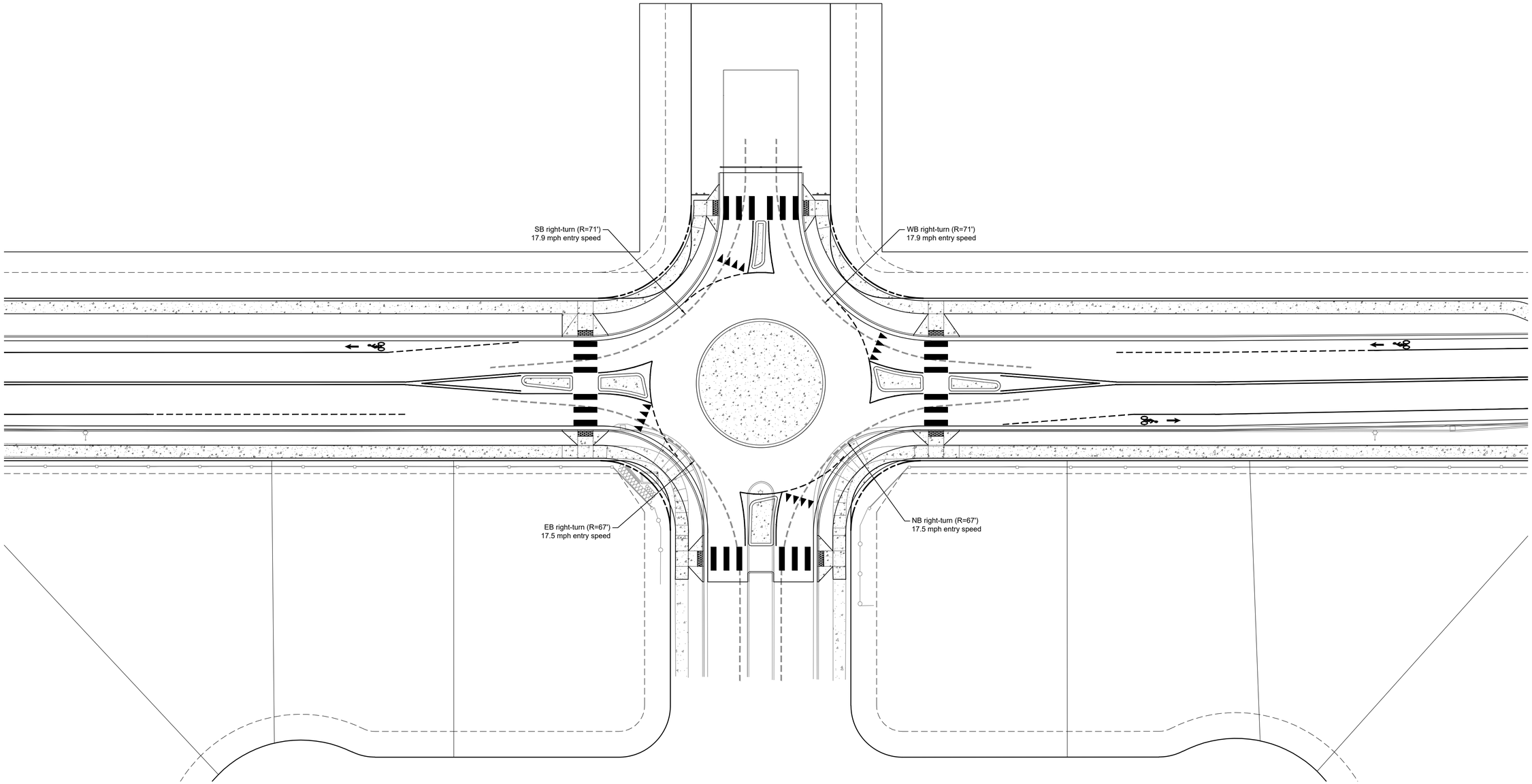

86' MINI-ROUNDABOUT
FASTEST PATH

B2

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9600 SW NIMBUS AVE, SUITE 100; BEAVERTON, OR 97008

DRAWING BY: *JEJ*
PREPARED FOR: *City of Newberg*
PLAN ISSUE DATE: *12/18/2019*
PLAN ISSUE PURPOSE: *Alternative Analysis*

N
W E
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SCALE: 1" = 20'
0 20 40 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT
NEWBERG, OREGON

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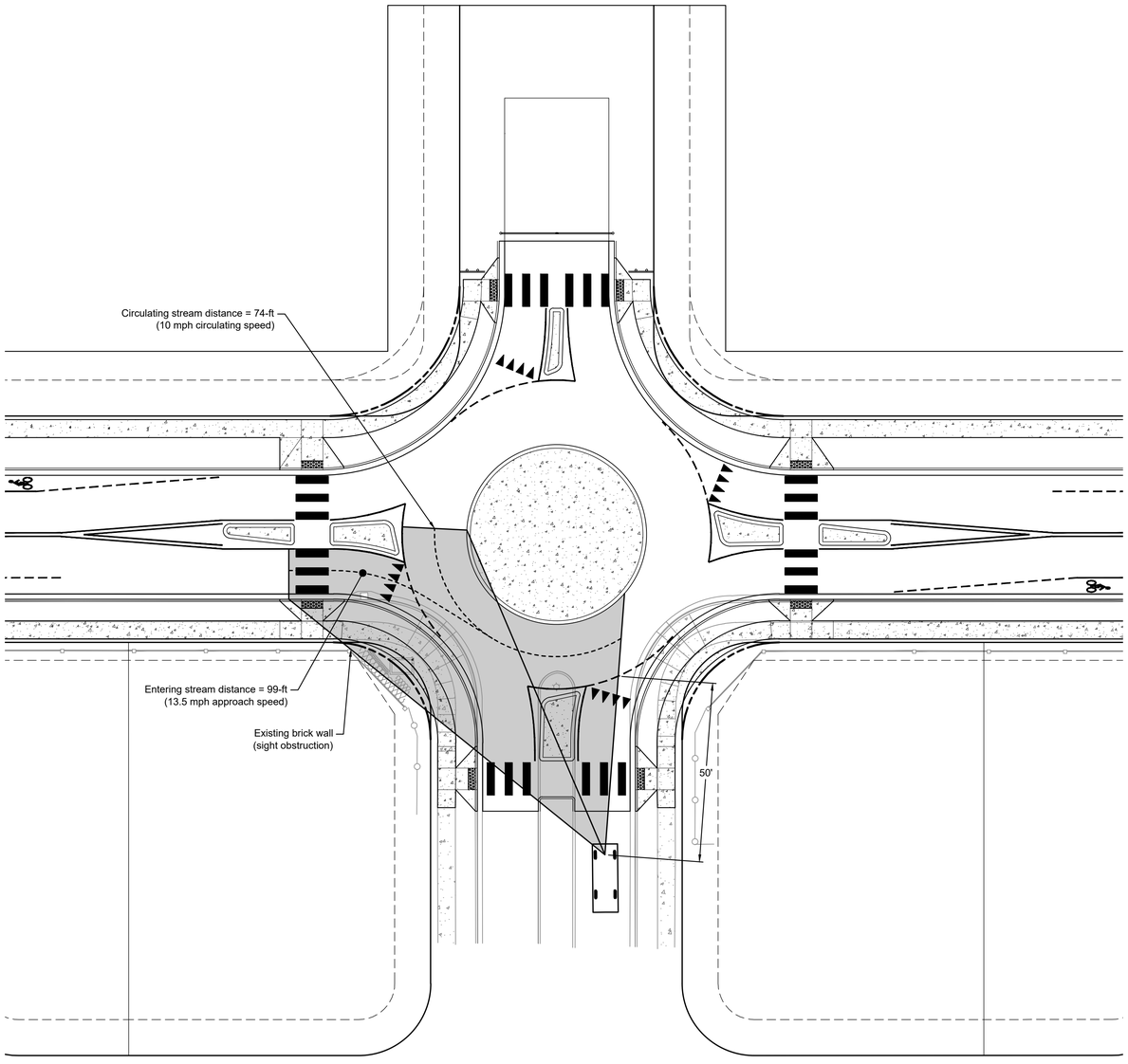
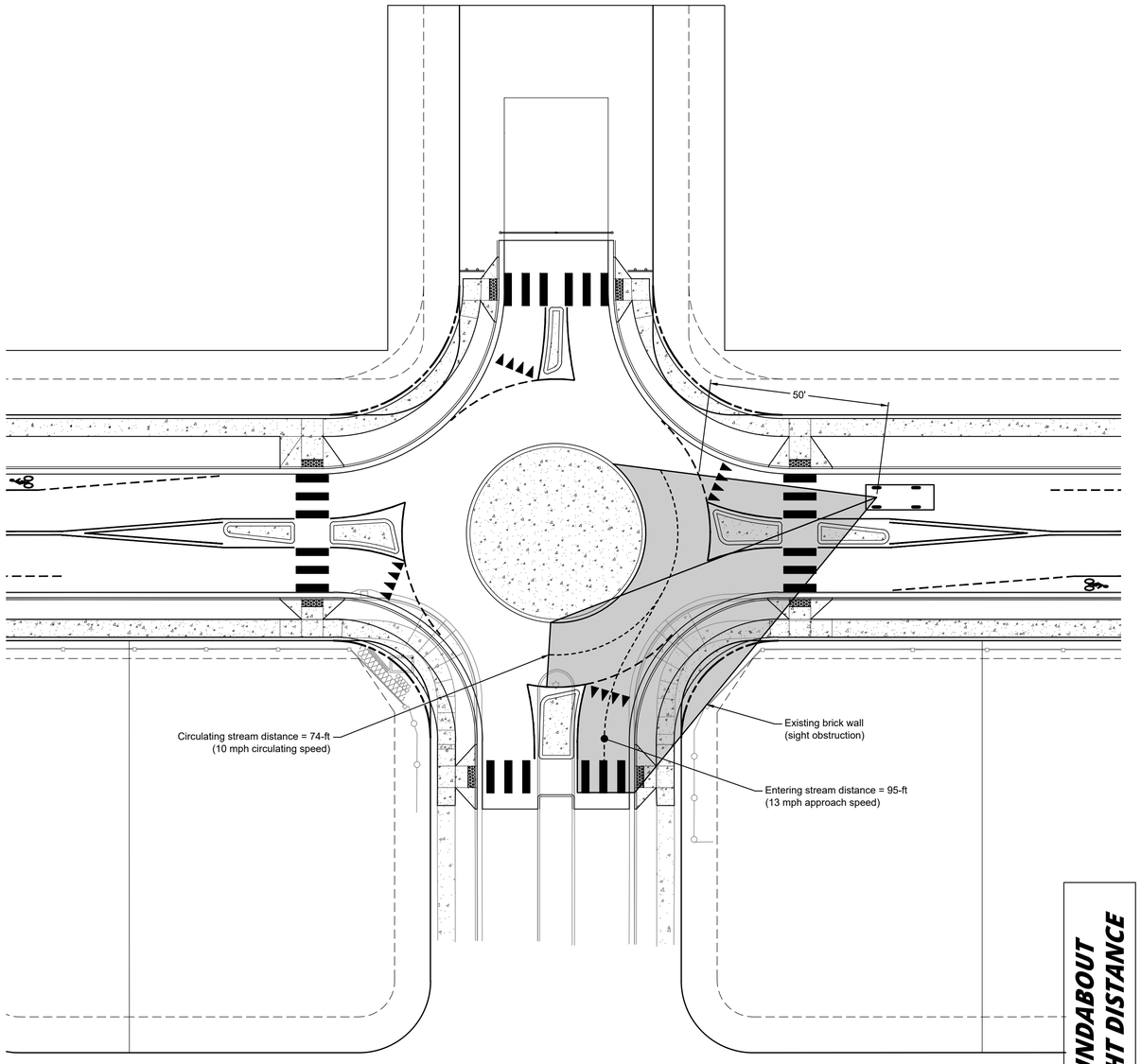


Northbound
Available Intersection Sight Distance = 99-ft
(13.5 mph conflicting approach speed)



Westbound
Available Intersection Sight Distance = 95-ft
(13 mph conflicting approach speed)

86' MINI-ROUNDABOUT
AVAILABLE SIGHT DISTANCE

B3.1

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N W E S

SCALE: 1" = 20'
0 20 40 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT
NEWBERG, OREGON

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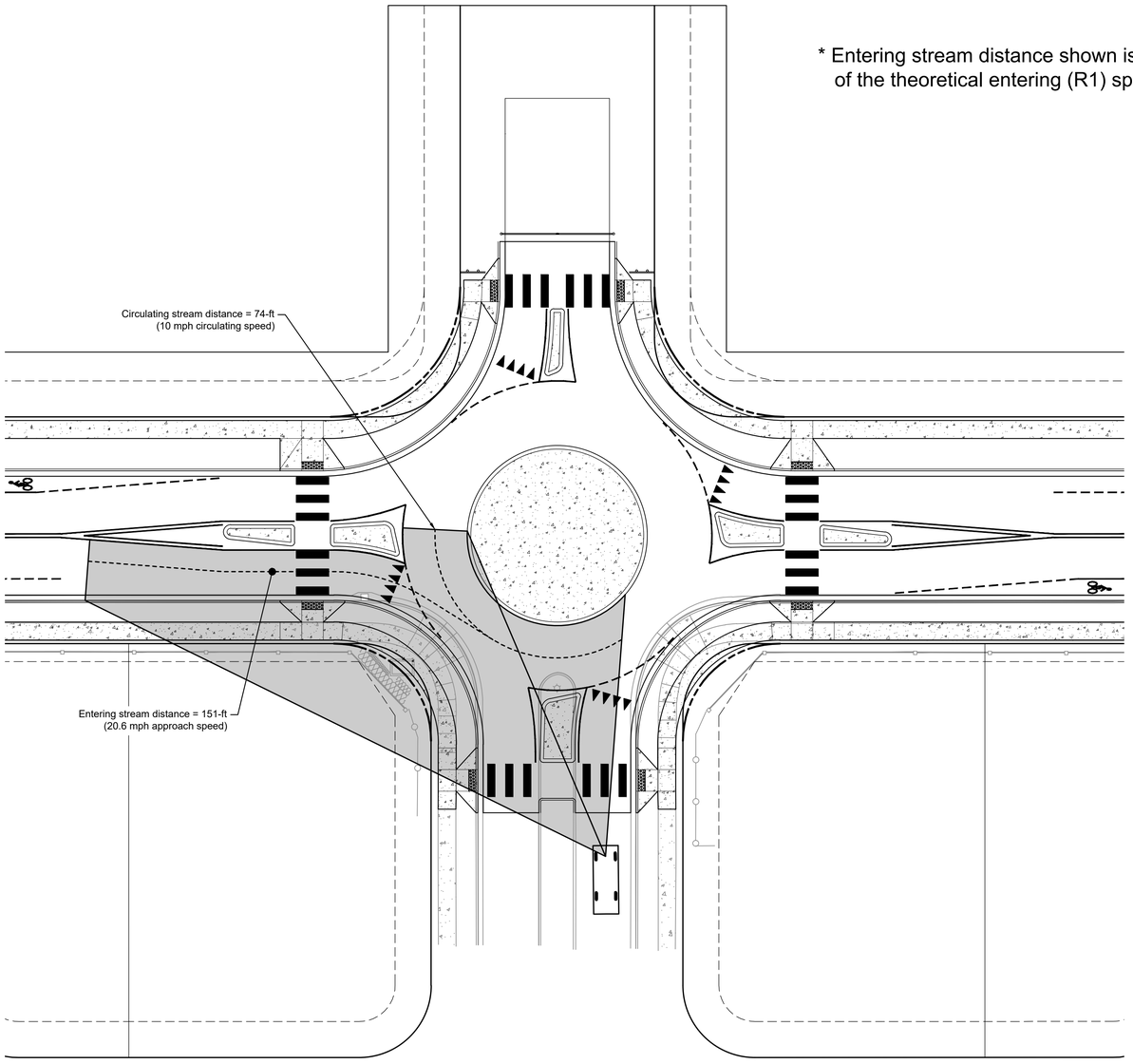
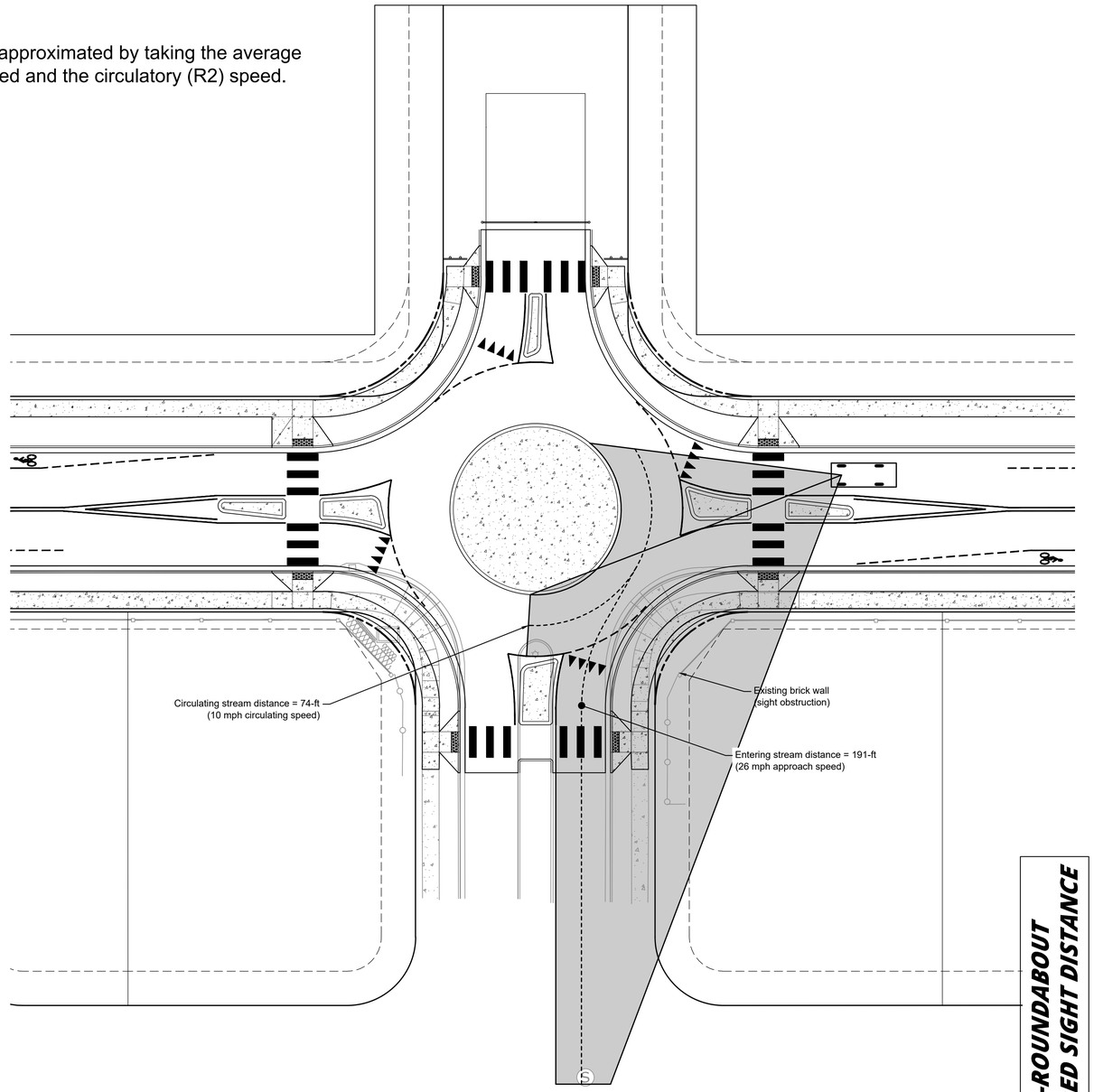
* Entering stream distance shown is approximated by taking the average of the theoretical entering (R1) speed and the circulatory (R2) speed.



Northbound
Recommended Intersection Sight Distance = 151-ft
(20.6 mph conflicting approach speed)



Westbound
Recommended Intersection Sight Distance = 191-ft
(26 mph conflicting approach speed)

86' MINI-ROUNDABOUT
RECOMMENDED SIGHT DISTANCE

B3.2

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N W E S

SCALE: 1" = 20'
0 20 40 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT
NEWBERG, OREGON

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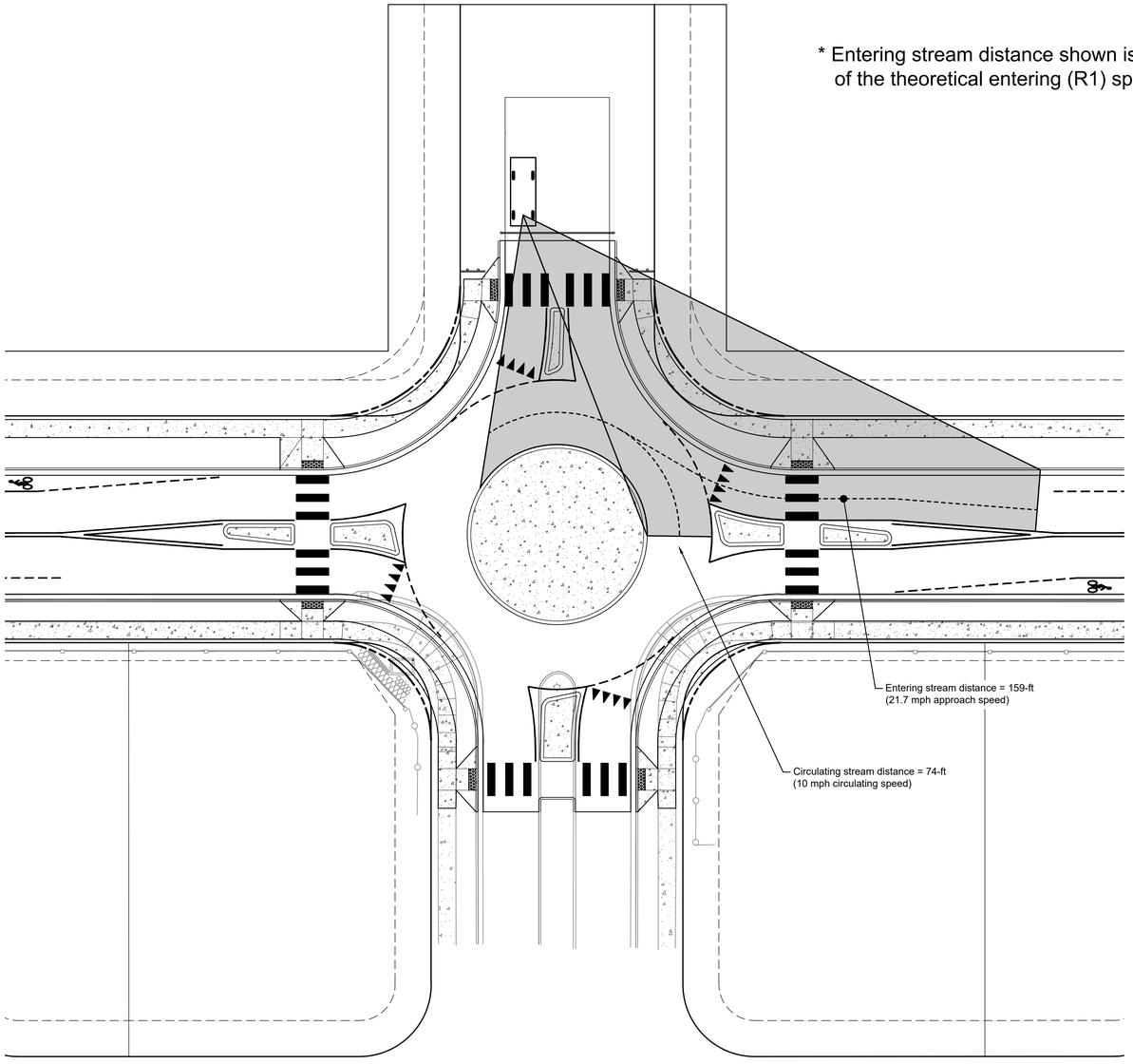
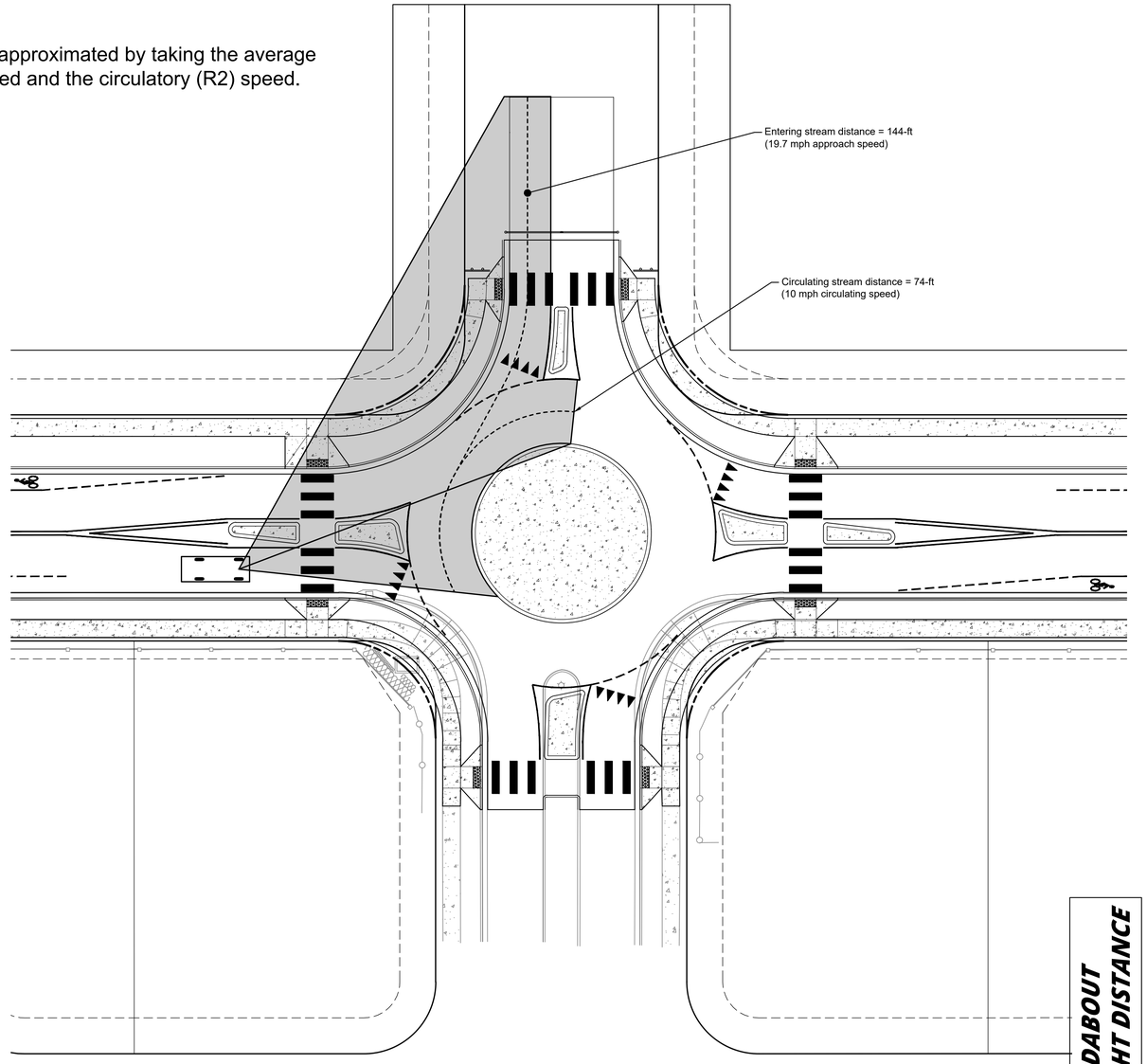
* Entering stream distance shown is approximated by taking the average of the theoretical entering (R1) speed and the circulatory (R2) speed.



Southbound
Recommended Intersection Sight Distance = 159-ft
(21.7 mph conflicting approach speed)



Eastbound
Recommended Intersection Sight Distance = 144-ft
(19.7 mph conflicting approach speed)

86' MINI-ROUNDABOUT
RECOMMENDED SIGHT DISTANCE

B3.3

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N W E S

SCALE: 1" = 20'
0 20 40 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT
NEWBERG, OREGON

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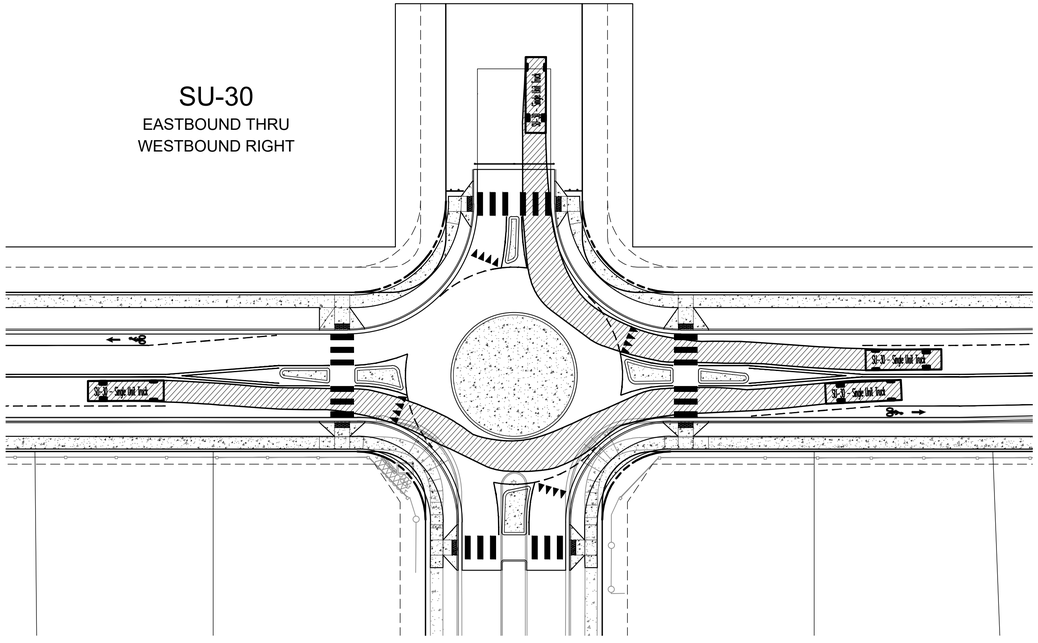

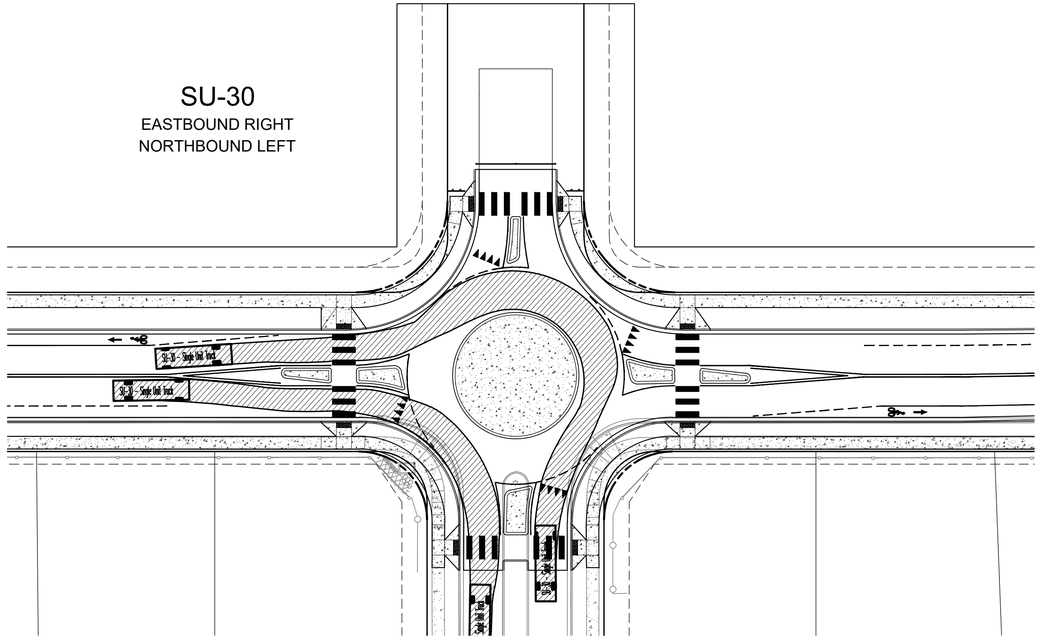

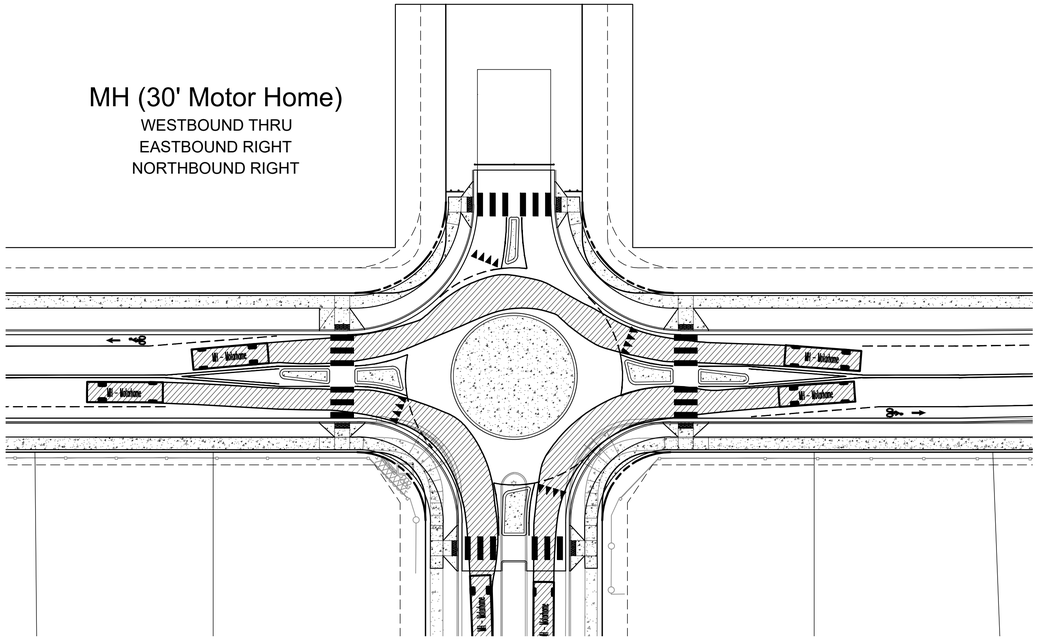

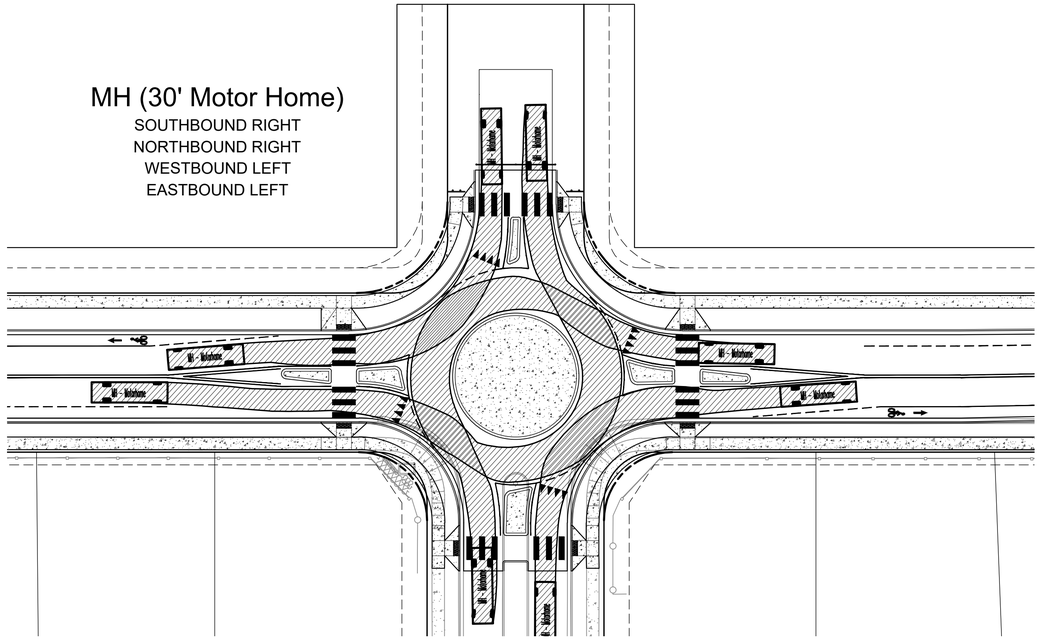

86' MINI-ROUNDABOUT VEHICLE TRACKING

Vehicle Tracking 2020
Speed = 5 mph

B4

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SCALE: 1" = 30'
0 30 60 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT

NEWBERG, OREGON

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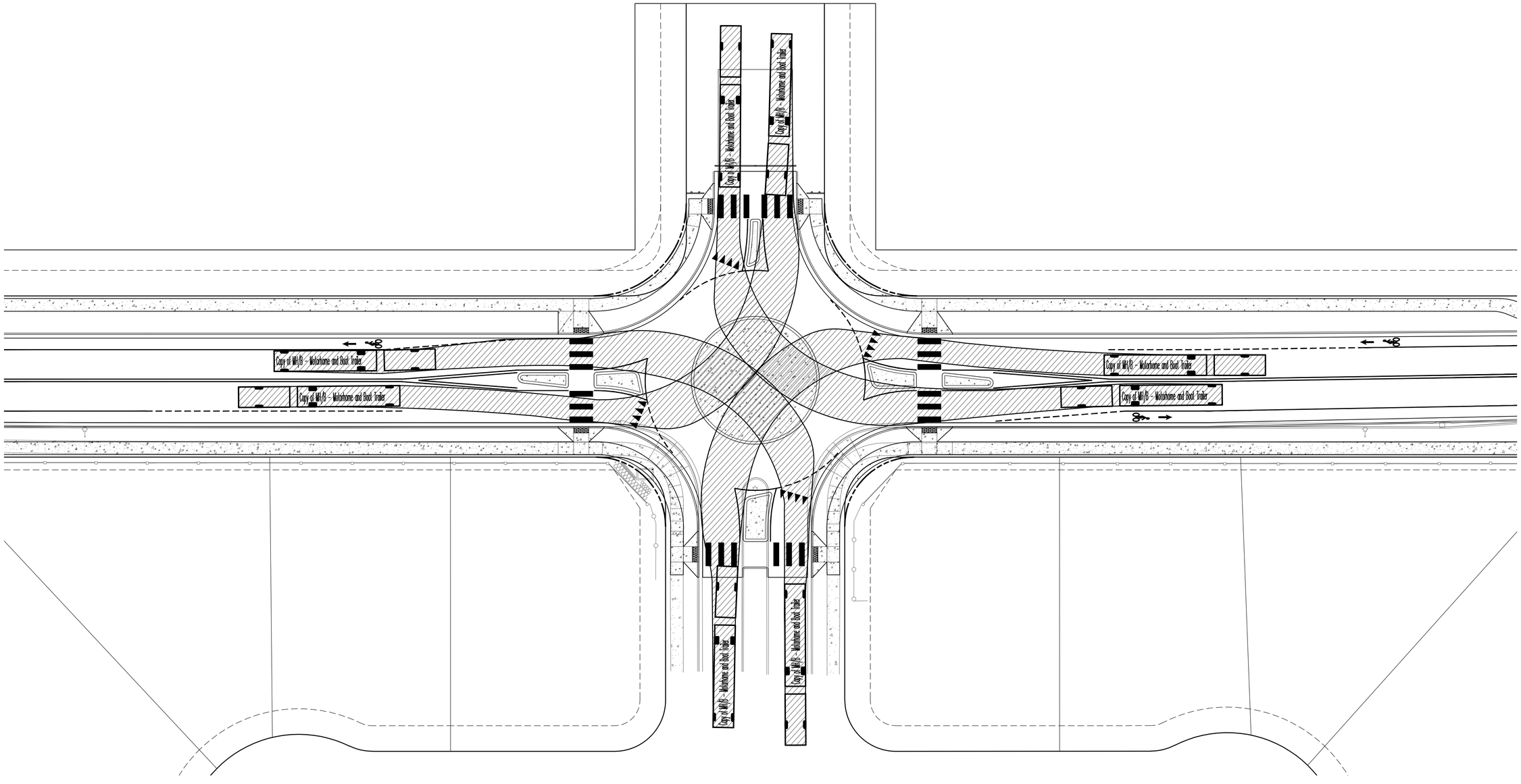

40' Motor Home and Boat Trailer - Left-Turn

86' MINI-ROUNDABOUT VEHICLE TRACKING

Vehicle Tracking 2020
Speed = 5 mph

B5

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SCALE: 1" = 20'
0 20 40 FT

EAST CRESTVIEW DRIVE IMPROVEMENT PROJECT

NEWBERG, OREGON

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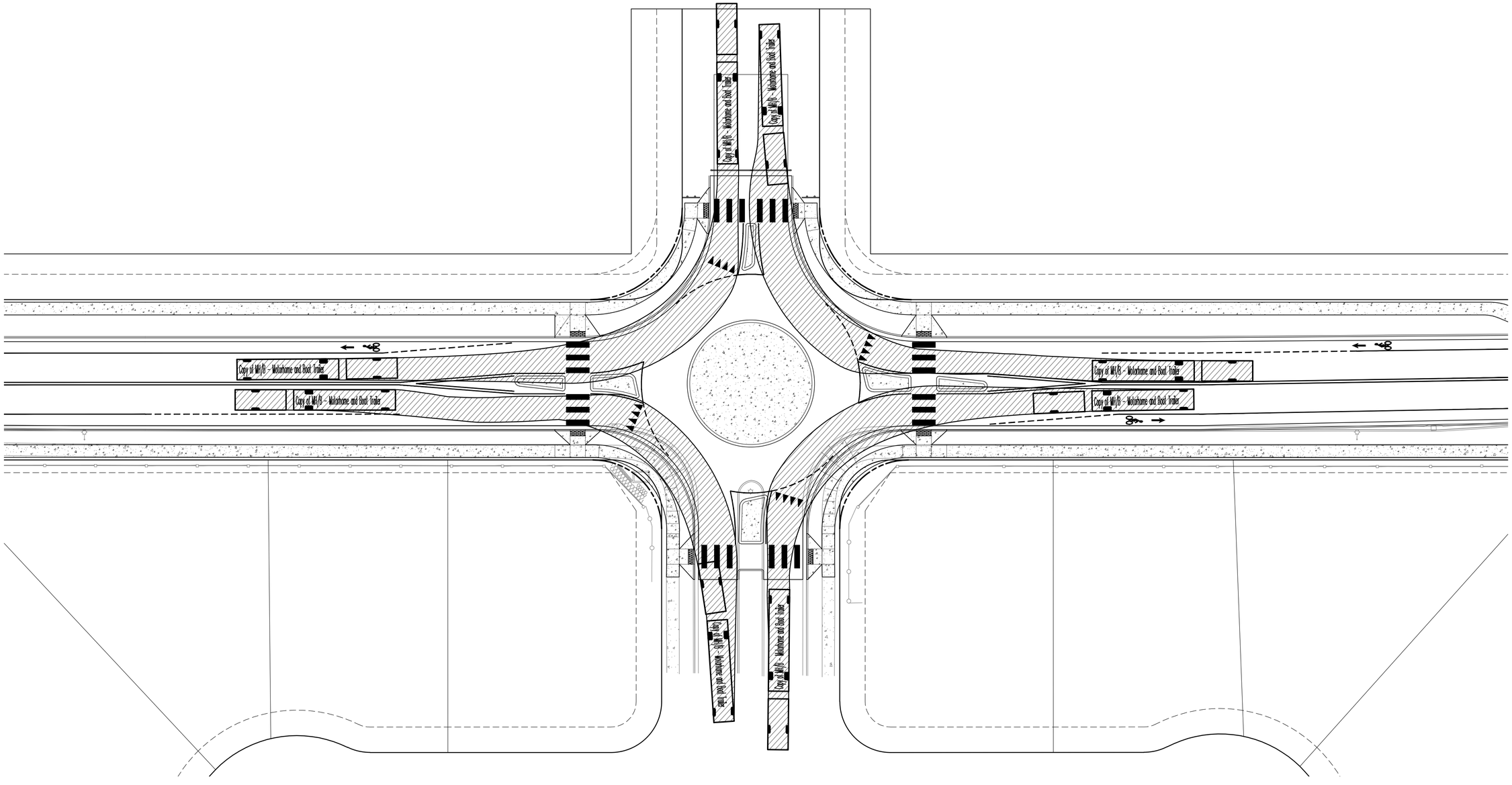

40' Motor Home and Boat Trailer - Right-Turn

86' MINI-ROUNDABOUT
VEHICLE TRACKING

Vehicle Tracking 2020
Speed = 5 mph

B6

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SCALE: 1" = 20'
0 20 40 FT

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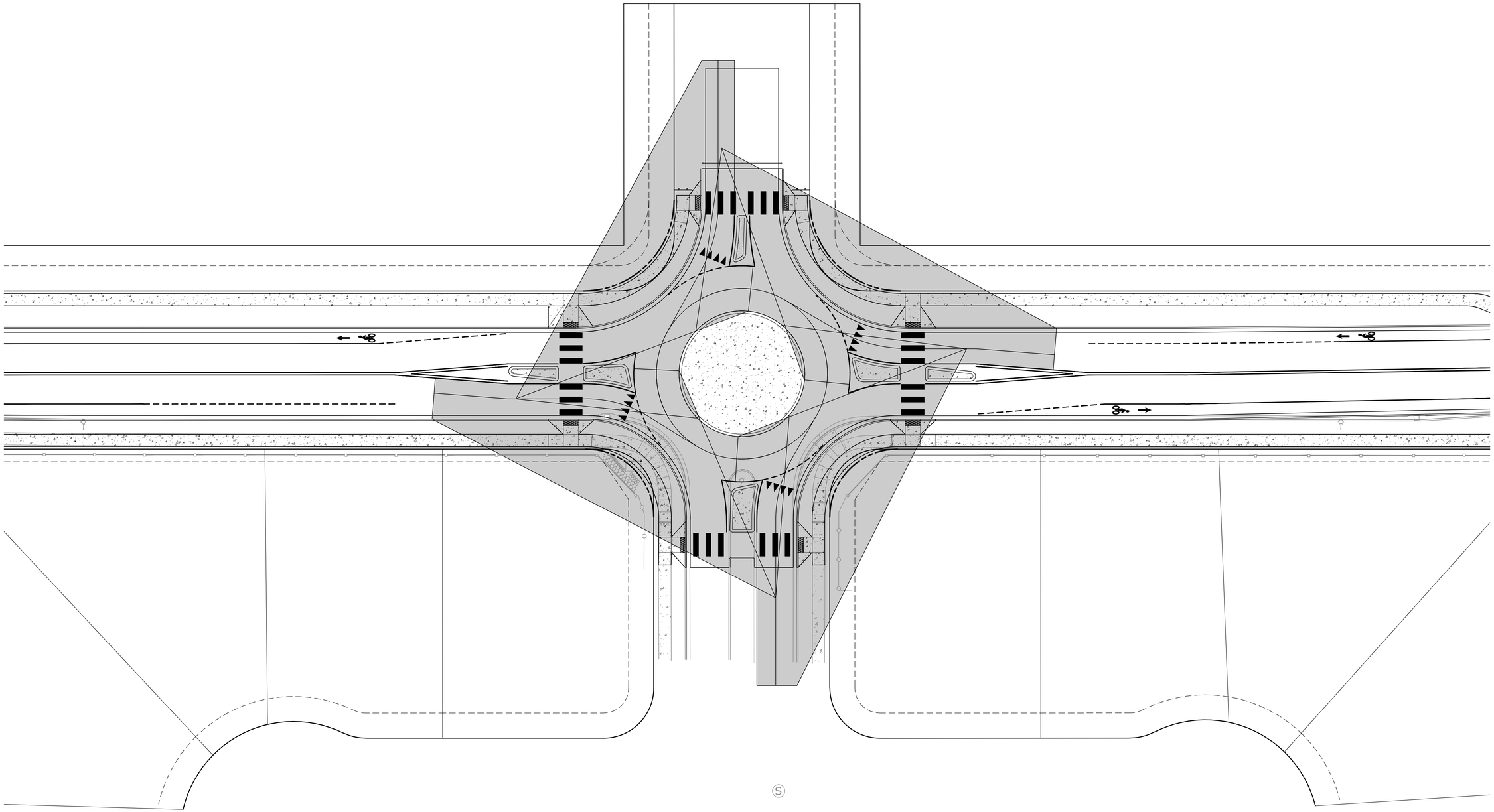

Intersection Sight Distance
20 mph approach speed / 10 mph circulating speed

86' MINI-ROUNDABOUT SIGHT DISTANCE

B7

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0 20 40 FT

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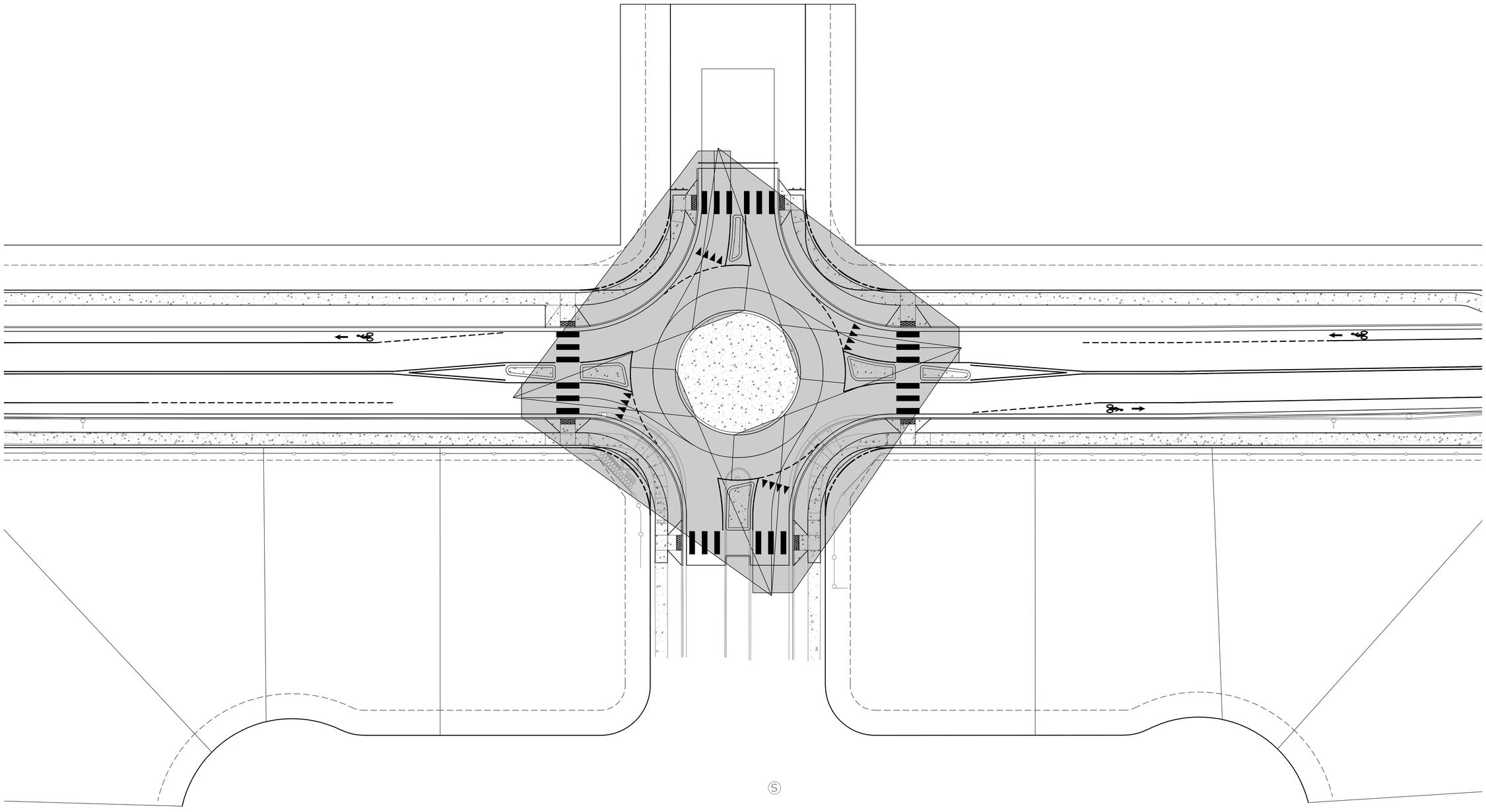

Intersection Sight Distance
15 mph approach speed / 10 mph circulating speed

86' MINI-ROUNDABOUT SIGHT DISTANCE

B8

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0 20 40 FT

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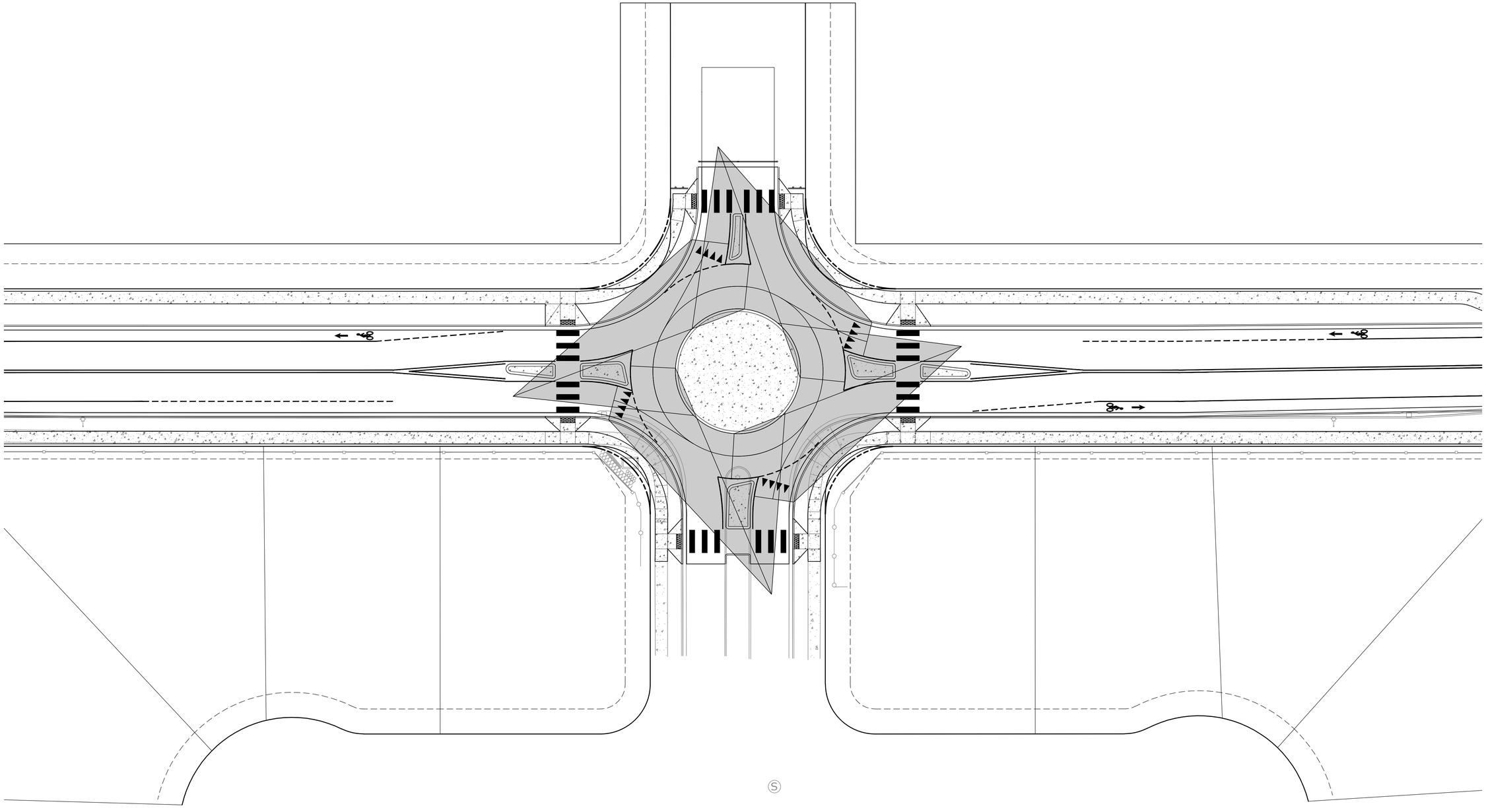

Intersection Sight Distance
10 mph approach speed / 10 mph circulating speed

86' MINI-ROUNDABOUT SIGHT DISTANCE

B9

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SCALE: 1" = 20'
0 20 40 FT

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NEWBERG, OREGON

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